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FLIGHT

AIRCRAFT, SPACECRAFT, MISSILES

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Promise . . .

IF no calamity has occurred to mar the stately cavalcade of Royal Aeronautical Society main lectures, Morien Morgan, the Air Ministry's Scientific Adviser, will by now have pronounced on the promise and problems of supersonic airliners. In the weeks ahead his paper—summarized on page 388—will be weighed and gauged by the foremost aircraft designers and the principal airline operators of the world. At their elbows they will have their shrewdest economic advisers, for the supersonic venture in air transport remains in a precarious state of unbalance on the knife-edge of economics. Meanwhile, the purely technical difficulties are seen to be increasingly tractable and the public utterances of designers, in America at least, are voiced in tones of rising confidence. It would be agreeable if these expressions of reassurance were wholly and firmly buttressed by technical conviction; but alas, above the measured words of the engineer the shrill spieling of the public-relations director has been too frequently audible.

No one, however, can regret the stimulus, as well as the amusement, afforded in recent months by the international supersonic debating society. To these lively proceedings the British team has made a modest contribution. Not unnaturally that same modesty has sometimes been construed as vacuity. This is a mistake and a pity, for British brains have not only been vigorously exercised along the road to commercial supersonics; they have—more important—been coached and co-ordinated in a degree quite unprecedented in the history of aeronautical development. This fact is now appreciated by our American rivals, and we predict that Mr Morgan's paper will be accorded in America a status of uncommon importance among the literature of applied supersonics. It is stimulating in its very sobriety, as witness the declaration "For medium ranges (stage lengths of 1,500 nautical miles) it is suggested that current advances in aerodynamic knowledge of sweepback will allow cruising speeds to rise to M1.2". This will be set against a typical American view recorded in this journal in recent weeks that "Speeds below Mach 2 appear to have no substantial advantages over high supersonic speeds."

. . and Problems

But even the M1.2 1,500-miler is foreseen by Mr Morgan as having increased operating costs, though not largely so. The most attractive field of supersonic transports, however, is long range which, of course, means London - New York. Mr Morgan examines the technical factors and shows that "reasonably economic" aircraft can be evolved at about M1.2. The regime M1.2 to M1.8 he dismisses as "unattractive," but the region M1.8 to about M3 he describes as being singularly attractive in terms of "potentially economic" aircraft. Nowhere (in the abstract available to us as we write, at least) does he give hope for appreciable cost reduction, and there is no implied concurrence in the Convair belief that a Mach 3 airliner would have a 12 per cent lower operating cost per seat mile than a subsonic jet if both were operated at their design range.

Thus the true importance of Mr Morgan's paper is not that it gives encouragement for the development of supersonic airliners (which it certainly does), but that it is a blunt reminder that such craft are by nature exotic and expensive, and that the airliner that Britain *must* build (as distinct from *could* build) is one that not marginally raises, matches, or even marginally reduces operating costs, but one that slashes them into fractions. This aeroplane will be neither exotic nor supersonic.

FROM ALL QUARTERS

EMBARKING in HMS "Bulwark": Whirlwind HAS.7s of 848 Sqn, which with 42 Commando, Royal Marines, form the new carrier's complement ("Flight," Jan 22)

Another from Hovercraft Island

BRITAIN'S second hovercraft, it was disclosed last week, is nearing completion in the Isle of Wight, quite near to where Saunders-Roe pioneered such vehicles nine months ago. The manufacturers are Britten-Norman Ltd and the Cushioncraft, as their vehicle is called, is intended to test the commercial application of hovercraft in regions like Ecuador, Colombia, the Sudan and West Africa in which the company have interests through their associates Crop Culture (Aerial) Ltd.

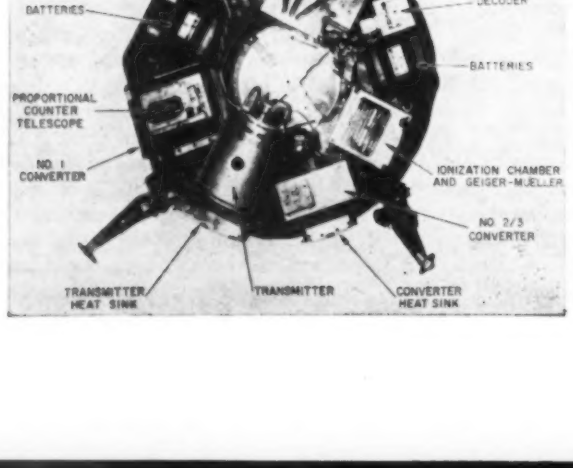
The Cushioncraft has a maximum diameter of 20ft and will be powered by a Coventry Climax engine. Propulsion is to be by two helicopter tail rotors. Some 7,000 man-hours have been devoted to development, at a cost (according to the *Daily Telegraph*) of about £10,000. Some of this has been contributed by the banana-growing and importing company Elders and Fyffes, who hope to operate the Cushioncraft in the Cameroons. The managing director of that company, H. J. Stockley, is reported as saying: "It was at our instigation that this development was embarked upon. If the craft is successful it will save us the cost of building roads from the plantations and will provide the means for a quicker and smoother transport for a fragile and perishable fruit. . . . I can foresee all our produce being carried in this way in a couple of years."

Super Broussard in America

MORE details have come to hand of the agreement signed in Wichita on February 16 between the Cessna Aircraft Company and Avions Max Holste, briefly announced in *Flight* last week.

The construction and sale of all present and future Max Holste products—the chief of which is the MH-260 Super Broussard, due to fly this month—will remain under Holste control. But Cessna, who have acquired a minority interest in the French firm, may by agreement manufacture Holste products in the US. Marketing, sales and after-sales service in the US and Canada will be taken over by Cessna, who will place their sales organization at the disposal of Max Holste as it is required. In turn, Cessna are to give Max Holste the right to market their range of executive aircraft in Europe and Africa, and following specific agreement certain of Cessna's products may be manufactured in France.

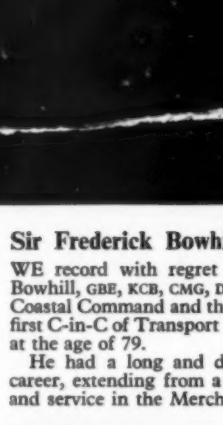
This is the second Franco-American agreement of this kind announced within recent weeks. A note on co-operation between Douglas and Sud-Aviation in the manufacture and sale of the Caravelle appeared in *Flight* for February 19.



Sir Frederick Bowhill

WE record with regret that Air Chief Marshal Sir Frederick Bowhill, GBE, KCB, CMG, DSO, who during the last war commanded Coastal Command and the Atlantic ferry organization and was the first C-in-C of Transport Command, died in London last Saturday at the age of 79.

He had a long and distinguished maritime and aeronautical career, extending from a seagoing education in HMS *Worcester* and service in the Merchant Navy from 1896 onwards (he was a Master Mariner) to an appointment as Chief Aeronautical Adviser to the Ministry of Civil Aviation from 1946 until his retirement in 1957. His flying experience dated from early 1913, when he qualified as a pilot, and during the First World War he served in the Naval Wing of the RFC, in the RNAS and the RAF, and in addition to winning the DSO and Bar was six times mentioned in despatches. In the inter-war years he was Director of Organization and Staff Duties at Air Ministry from 1929 to 1931; AOC the Fighting Area, RAF Uxbridge, from 1931 to 1933; and Air Member for Personnel from 1933 to 1937.



Sir Frederick—a characteristic wartime portrait

Sir Frederick became AOC-in-C Coastal Command in 1937, holding that appointment until 1941. From 1941 to 1943 he commanded Ferry Command, then was AOC-in-C Transport Command from 1943 until his retirement from the RAF in 1945. When he gave up his MTCA post during 1957 the then Minister, Harold Watkinson, expressed the Government's thanks for Sir Frederick's "unique services to the State."

Big Lift Begins

THE largest military airlift exercise ever held in peacetime, designated Big Slam/Puerto Pine, began last Monday, March 14, with the transport of troops and equipment from the USA to Puerto Rico by aircraft of the US Military Air Transport Service. The totals to be carried during the 15-day exercise are no less than 22,000 troops and 12,000 tons of cargo.

The MATS contribution will be twofold: in addition to using 220 aircraft for the initial deployment of the troops from 18 bases in the US to two in Puerto Rico, and their return, a similar number of aircraft engaged on routine MATS operations will fly intensively, the overall effect being to raise the daily utilization rate of all MATS aircraft from five to eight hours per day. A total of 46,000hr by almost 450 strategic airlift aircraft is scheduled.

Big Lift Ends

ON the occasion of the delivery of the 60th Thor IRBM to the RAF (reported on pages 359-360), the Douglas Aircraft Co announced that "more than 25 million pounds of Thor missiles and allied ground support equipment have been airlifted from the Los Angeles area and the East Coast to England since the high-priority air transportation project began 18 months ago." This was stated

LONELY LABORATORY: News of the placing in solar orbit of Pioneer 5 is given on page 358. This is a top view of the instrumentation; the four arms are those which carry the "paddlewheel" solar batteries, and on the reverse side are a magnetometer, micrometeorite electronics and an aspect (or Sun) indicator. Maximum transmitter power is 150W

***CALLED YETI** after the elusive and abominable snowman, this ski-equipped Pilatus Porter has been specially prepared for the forthcoming Swiss expedition to Dhaulagiri in the Himalayas*

to have included 20m lb of ground support equipment flown in C-124s and C-133s from the Douglas/USAF Thor supply depot at Long Beach, Los Angeles; 50ft liquid-oxygen tanks each weighing 34,000lb ferried in C-133s from Massachusetts; and bulky diesel generators flown from Dover, Delaware.

The USAF plant representative at Santa Monica told *Flight* on this occasion that 677 flights had been made in the Thor delivery programme, of which 600 had been by C-124 Globemasters. The amount shipped by surface transport totalled 18m lb. No official statement was made on the subject of the delivery of Thor warheads, but *Flight* understands that none has been carried by MATS.

"Indignant Frustration" in Gliding

PRESENTING his report as chairman of the British Gliding Association, at the a.g.m. in London on March 12, Philip Wills said: "Never in the 28 years in which I have been in the gliding movement have I experienced such a general feeling of indignant frustration. Our difficulties are exactly what they were a year—and ten years—ago, and our new Government has shown neither understanding of them nor any desire to help solve them."

After pointing out that Germany had re-established over 500 civil gliding clubs since the war, compared with Britain's 41, Mr Wills paid a tribute to the work of the Kemsley Flying Trust and suggested that the Government should "assume as a duty" the provision of a similar revolving interest-free fund, to ensure the growth of sporting flying at "trivial cost" to the nation.

During 1959 a total of 27,384 hours was flown from 157,540 launches at club sites—both considerable increases over last year's figures. The excellent weather produced a record cross-country distance of 78,892 miles; the number of pilots was now 4,286 and there were 294 gliders currently operating.

VTOL Ejection

WHEN the Ryan VZ-3RY Vertiplane deflected-slipstream VTOL aircraft crashed at the beginning of the month, the test pilot, Glen Stinnet, escaped by using his Martin-Baker Mk VRN.4 ejection seat. The successful escape was not made at zero speed and altitude, but the seat is designed for such a contingency.

The Martin-Baker Mk VRN.4 seat is also installed in the Short SC.1 flat riser and the Dornier Do29 tilting-propeller prototype. Probably the first successful escape from a VTOL machine at near zero speed was Auguste Morel's from the SNECMA Coléoptère tail-sitter last summer. He used a Sud Aviation ejection seat at a height of something over 100ft. The actual height and speed at which Glen Stinnet escaped have not been specified.

Boscombe Down AOC

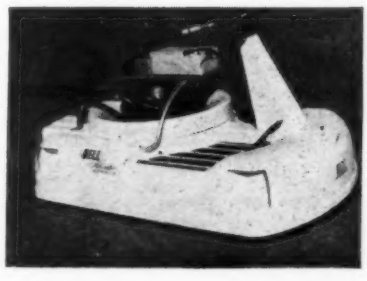
NEW AOC the Aeroplane and Armament Experimental Establishment at Boscombe Down is Air Cdre J. F. Roulston, CBE, DSO, DFC. He has been Task Group Commander of the Reinforcement Party at Christmas Island in the Pacific since February 1958 and in his A & AEE appointment succeeds Air Cdre A. E. Clouston, whose tour of duty ends this month.

A South African, Air Cdre Roulston came into the RAF on a short-service commission in 1936. During the war he commanded at different times Nos 223 and 55 Sqns and No 232 Wing, Desert Air Force. He won the DFC in 1940, was mentioned in despatches in 1941, awarded the DSO in 1943 and made an OBE in 1945.

Replacing the V-Bombers

V-BOMBER replacements and the advantage of mobile bases were two subjects touched on by AVM H. A. V. Hogan, Senior Air Staff Officer of Flying Training Command, at the Southampton University Air Squadron dinner last Friday. Within the context of the manned aeroplane "coming back into its own again" he said he was convinced that the RAF would be "calling for replacements for the V-bombers"; and with the TSR.2 as well the RAF would be in the flying business "for a long time to come." AVM Hogan summed this up as implying that the dust was settling on the Defence White Paper of 1957; and from his personal experience of FAA operations went on to stress the advantages of mobile bases like Q-ships or submarines.

***NEW CONFIGURATION** of the Lockheed JetStar—with four Pratt and Whitney JT12s, reversers, high-lift wing and dual-wheel undercarriage. Customer deliveries will begin in January 1961*



***NO WHEELS, NO WINGS:** New picture of the Bell air scooter (first news, "Flight," February 5). The handlebars do not, as originally surmised, serve only to carry engine controls: they may well be connected to the shutters of the control ducts at each corner revealed in this picture*

IN BRIEF

Vertol Aircraft Corporation is to be acquired by the Boeing Airplane Co on March 31 and will become the Vertol Division of Boeing.

We regret to record that Capt D. A. Templeton of Scottish Aviation was killed at Johat, Assam, on March 10 in an accident to a Twin Pioneer he was demonstrating.

Three more D.H.C. Otters are to be delivered to Indonesia this year, following successful evaluation by AURI (the Indonesian Air Force) of two Otters delivered in 1958 and a further two last year.

Bristol Siddeley have been permitted to disclose that the Olympus 21 has a dry rating of 20,000lb. The low-pressure spool has a zero stage (intake diameter 42in). This engine may power later Vulcan 2s, and represents a stage in powerplant development for the TSR.2.

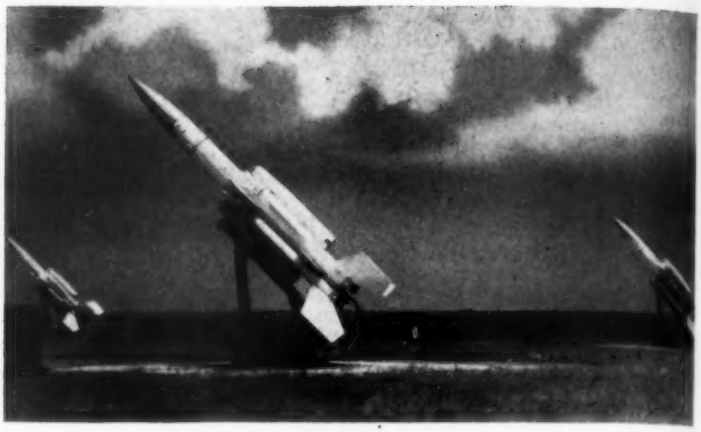
A BOAC Comet 4 (Captain N. A. Mervyn-Smith) with 24 passengers on board was severely damaged at Madrid last Monday evening when, it is reported, the undercarriage collapsed on landing. No one was injured.

A memorial service for the late C. C. McCarthy-Jones, a former CO of No 601 Sqn, RAuxAF, who died suddenly in Lagos on February 17 (*Flight*, March 4), will be held in the RAF Church, St Clement Danes, at noon on Saturday, March 26.

A Dassault Etendard IVM, powered by a SNECMA Atar 8, is now at RAE Bedford undergoing catapult and arresting trials. Such tests are a preliminary to actual carrier operation and Bedford is often used by foreign aircraft because of its extensive facilities.

A civilian airframe fitter at No 15 Maintenance Unit, RAF Wroughton, has been awarded the Queen's Commendation for Valuable Service in the Air. The fitter, Hugh Reid, took over the controls of a Canberra after the pilot had blacked-out through oxygen failure at 35,000ft. He brought the aircraft down to 12,000ft, when the pilot recovered.

"FLIGHT" NEXT WEEK—a special issue on sport and business flying in Britain and America. Usual features will also appear.



This Air Ministry photograph is cryptically stated to portray Bristol Bloodhound surface-to-air guided weapons in service with an air defence missile squadron of RAF Fighter Command. Several Bloodhound bases are now being equipped, and the photograph is certainly the first to show truly operational missiles in their proper livery

Missiles and Spaceflight

PIONEER 5

Many "firsts" have already been achieved by the 90lb vehicle of this name, launched by Thor-Able from Cape Canaveral last Friday morning, March 11. Planned to orbit the Sun with a period of 265 days, Pioneer 5 has a period of 311 days, and passes within 8m miles of the orbit of Venus.

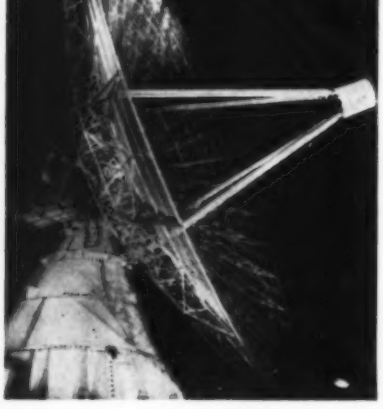
Solar batteries energize transmitters with a peak power of 150W. Not only is this far greater than in any previous spacecraft, but their power can be conserved by limiting periods of transmission to a few minutes every hour by command from Earth. The instrument used for this purpose is the radio telescope at Jodrell Bank (rented by NASA at £50 per hour), and early on Monday it was in contact with Pioneer 5 at a range of 407,000 miles. (Picture, page 356.)

CANADIAN BOMARCS

When the CF-105 Arrow was cancelled in February 1959, the Boeing IM-99B Bomarc was adopted in its place. According to the original agreement with the US government, Canada would have paid one-third of the total cost of the programme, the remainder being met by the US Defense budget. A revised agreement was revealed by Randolph Pearkes, Canadian Minister of Defence, on March 7. He said that his department will now be required to cover only the cost of constructing the bases, estimated at $15m (£5,360,000).

All the missiles and their launching equipment, representing a total investment of $72m (£25,725,000), will be supplied by the US without charge. Later, however, Canada might spend about $100m (£35,700,000) in contributions to an extension of the American SAGE electronic defence environment to cover the Dominion, and enable Bomarcs to be deployed efficiently. Two IM-99B bases have so far been named: at North Bay RCAF station, Ontario, and at Mont Laurier, Quebec. Both should be complete next year.

Below left, previously published several times in Soviet journals, this photograph is thought by NASA to portray the ballistic rocket used by the Soviet Union to launch the dog-carrying Sputnik 2 on November 3, 1957. The configuration and shape of the vehicle—and especially the bulges on its sides and the apparent fins—are curious



SATURN: BETTER AND SOONER

On January 22 we outlined the plans of the National Aeronautics and Space Administration to develop a much improved version of Saturn, the largest space-vehicle system at present being built in the West. It is now clear that this programme is regarded by NASA as its chief launching system for at least the next five years, and that every effort is being made to accelerate the development of a series of even better versions.

Speaking before a meeting of the American Rocket Society in Washington earlier this month, Milton W. Rosen, assistant director of vehicles in the Launch Vehicles office, confirmed that the first three-stage device, designated Saturn C-1, would be launched in 1964. The next model will be the C-2, with four stages, and plans are also in hand for a five-stage C-3. In each of these systems the last stage but one will be the S-IV, powered by four Pratt & Whitney LR115 oxy-hydrogen engines of 20,000lb thrust each. In the competition for this stage 22 firms were invited by NASA to participate; 35 attended the bidders' conference and bids were made by 11.

ATLAS: BIG PLUS, SMALL MINUS

During the past year the Convair Astronautics division and Bosch Arma have been working intensively to fit the all-inertial guidance system originally designed for Titan into the Atlas. Following extensive ground testing a complete missile has now successfully flown a 6,300-mile mission with the new system on board (but not coupled to the control system and engines). The launching took place from Cape Canaveral on March 8, and marked the first time the Bosch Arma system had flown in an ICBM.

The flight was the 22nd consecutive successful mission by Atlas C and D models, a record not yet equalled by any other large missile in the Western world. The run of good fortune came to an end two days later, when an Atlas launched from Cape Canaveral with operational Mk 3 nosecone and simulated warhead failed to rise more than 10ft. Counted-down in the late evening of March 10, the 85ft missile toppled over a few seconds after a slow lift-off, and blew up on the pad.

ASTRONAUTS NEXT YEAR

Perhaps mindful of what has happened in the past, the US National Aeronautics and Space Administration is being particularly guarded in its reference to what the Mercury Astronauts are to accomplish, and when. At a press conference in Cleveland on March 5, their spokesman, Col John Powers, merely asserted that the first man in space would be launched "sometime next year" (unless, as seems quite likely, the Soviet Union get there first).

Col Powers later confirmed that the mission would start at Cape Canaveral. For three days before the launch the Astronaut selected would be on a special diet, and on the final day he would be "completely isolated from all outsiders" so that he could "concentrate on the flight." The first mission will comprise three 90min orbits and recovery from the South Atlantic, but later Astronauts are scheduled to complete 19 orbits. (Earlier, some "up-down" flights may be made in Redstones.)

Each station of the ballistic-missile early warning system ("Flight," January 29) will have five tracking radars which will take over from the giant fixed detection arrays. This photograph shows the prototype tracker at the RCA Plant in Moorestown, New Jersey. Each such dish weighs 200 tons and is enclosed in a weatherproof plastic sphere (faintly visible in the background). One BMEWS will be built in Yorkshire

Missiles and Spaceflight . . .

PEACEFUL DELIVERY

Deployment of intermediate-range ballistic missiles with the Royal Air Force was completed last week with the delivery of the 60th and last Thor from the USA to Britain. This article describes the flight, by the Military Air Transport Service of the US Air Force, to collect and deliver the missile. The background to the entire Thor airlift programme will be the subject of a further article next week.

"YOUR routing is direct to Santa Monica via St Louis, Oklahoma and the scenic route. . . ." The crewcut, shirtsleeved briefing officer in the Operations Center at Dover Air Force Base, Delaware, flicked through his file of crew notices quietly, almost casually. "Without the permission of MATS you will not participate in public aerial demonstrations . . ." ("No barrel rolls?" asked the aircraft commander, thinking of his massive Globemaster) " . . Coffee in addition to that for meal requirements will cost 35 cents a gallon . . ."

The aircraft commander, Lt Clyde Turner, took the floor and continued to outline our flight-plan. It would be a 12hr 18min flight, and we were due to take off at 8 a.m.—in 1½ hours' time. Weather was generally good, but there was the possibility of moderate icing between St Louis and North Texas. "You may have heard," the lieutenant added, "that the bird we are picking up is the final Thor for the RAF. There is a possibility that Douglas may make a production of this, and on the way back we may have two colonels and a general aboard."

BY KENNETH OWEN

Illustrated with "Flight" photographs

Thus forewarned of the twin dangers to come of publicity and top brass, crew-members adjourned to eat breakfast and attend to flight formalities. The crew comprised, in addition to the aircraft commander, two pilots (Capt W. A. Yonker and Lt R. S. Edwards), two engineers (T Sgts H. L. Decker and M. W. Hiltunen) and a loadmaster (A/2c T. S. Magoon), and they belonged to the 40th Squadron of the 1607th Air Transport Wing, a unit of MATS Eastern Transport Air Force (EASTAF). The base at Dover, claimed to be the world's largest air cargo centre, had been closed for flying for three days by the fierce blizzards that had already refrigerated the East Coast (and *Flight*'s representative), but was expected to be open for take-offs again this morning. Even so, the local weather was still pretty bad. Airman Second Class Thomas S. Magoon confided that his Triumph T.R.3 was still buried under a sizeable snowdrift.

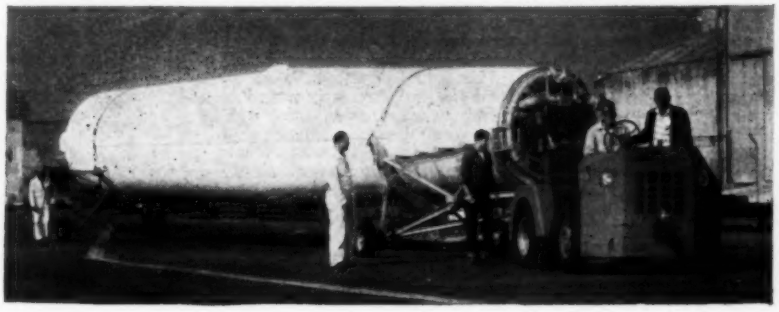
Two predictions made at the briefing did not come true. Because of an oil-pressure fault in one of the Pratt & Whitney R-4360 engines our take-off was delayed until just after noon; and this delay, in conjunction with a restriction against night landings at Santa Monica, meant that we would land at Norton AFB, San Bernardino, California, and fly on to Santa Monica and any Douglas "production" the following day.

My first impression of our C-124C as we drove out to it was of a big, ugly, ill-proportioned monster with a ridiculous glacé cherry added for a nose. After we had climbed through the crew-entrance hatch and into the assembly-hall of an interior, however, it was obvious that this was no monster, but an effective and hardworking cargo vehicle. Numerous tie-down rings were let into the floor, which also incorporated hatches to two under-floor compartments and the lift platform, which is used as an additional loading facility. The nose ramps were raised vertically and folded, flanking the central ladder which led up to the crew section. Along the sides were canvas, tubular-framed troop benches (mostly folded against the walls), while at the rear of the cabin was a triple bunk for which, on the outward trip at least, we were to be most grateful.

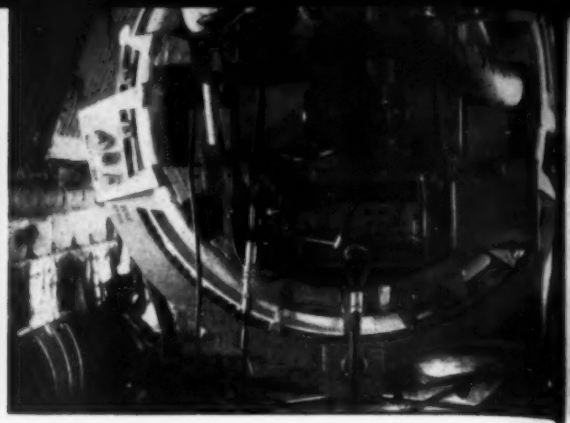
On the floor at the rear were the cable and pulleys used to load and unload the Thor. As part of the pre-flight checklist procedure, one of the engineer sergeants disappeared into the forward under-floor compartment and, much to my surprise, re-entered five minutes later through a side hatch from the wing. The explanation lay in a walk-way, or crawl-way, inside the wing which is used to provide servicing access to the engine nacelles—and, once at the outer engine, the quickest way back is up through a hatch in the nacelle and out on to the wing.

On the ceiling were two twin-hook travelling-crane units, running along longitudinal rails; and folded against the upper fuselage sides in the rear part of the aircraft were the floor-sections which, when lowered and locked, help to convert the Globemaster into a two-deck passenger aircraft able to carry 200 troops.

The crew compartment is a thoroughly workmanlike affair. Looking down through the cockpit windscreen, I first wondered whether there ought not to be a control tower under me rather than an aeroplane, but one soon gets used to the altitude. Behind the co-pilot's seat, along the right-hand side of the compartment, is the engineer's position, opposite which on the left is the navigator's



The 60th Thor delivery flight to the RAF began at Santa Monica on March 8 with the roll-out of the missile from the Douglas plant (below) and its loading aboard another Douglas product, a C-124C Globemaster of the 40th Air Transport Squadron (heading photograph). Left, the author talks with crew-members Yonker, Hiltunen, Decker, Turner, Magoon and Edwards before the flight



PEACEFUL DELIVERY . . .

station—occupied on transatlantic or other overseas flights, but not during trips within the USA. Aft of the navigator's table is the radio operator's position—not now used as such—and in the rear of the compartment are rest bunks for the crew.

The 2,500-mile flight from Dover to Norton was made at 200kt TAS at heights between 8,000 and 13,000ft and, with headwinds all the way, took us 12hr 13min. Snow on the ground extended as far west as Amarillo, Texas, at which point we were flying into a burnished red-gold picture-postcard of a sunset. The low cargo-density on this part of the trip (another writer and I were the only occupants of the cavernous whale-belly) made possible a half-mile walk as an appetizer before dinner—interpreted as 18 return trips up and down the cabin, from the aft bunks to the sloping fore-part of the floor, before eating our packed flight-meal. At 9.20 p.m. local time we taxied in at Norton and parked next to a turboprop C-97 in front of the operations building.

Next morning the warm California sunshine filtered down to us at Norton (and to Douglas at Santa Monica) through a persistent grey fog, forcing the postponement of our 75-mile flight to Santa Monica until after lunch. On arrival there we were greeted by the USAF plant representative at Douglas, Col Clair A. Peterson, who was to accompany the Thor and us on the return trip. Our departure was scheduled for the following morning, Tuesday, March 8.

It was about 9.30 on Tuesday morning that the leading lady in this particular production came on-stage—or, to be more precise, that the 60th Thor for the RAF was towed out of the Douglas plant and positioned in front of the mouth-open Globemaster for Press and television photography prior to loading. USAF "Executive management responsibility" for Thor has now passed from the Ballistic Missile Division (of Air Research and Development Command) to the San Bernardino Air Materiel Area (of Air Materiel Command) with headquarters at Norton AFB, and top-ranking officers of SBAMA—including the commander, Maj-Gen Ben I. Funk—were among the supporting cast on this occasion. One of three RAF wing-commanders on liaison duties with SBAMA, Wg Cdr P. L. Hancox, was also present.

The full-scale Thor was not the only piece of hardware we were taking home with us on the aircraft, for Col Peterson was to carry a plaque from Gen Funk addressed to Air Marshal Sir Kenneth Cross, C-in-C Bomber Command, to mark "the successful deployment of the Thor IRBM in the United Kingdom." The photographing of the plaque and the people involved, to the satisfaction of the various news media, took appreciably longer than the loading of the actual missile.

Having a big white tube called Thor as a travelling companion somehow seemed to make the Globemaster interior a much smaller place. Some idea of our abbreviated accommodation can be obtained from the interior photographs at the top of this page. The view across the fuselage was now limited to the feet of the passengers opposite, seen beneath the missile, and there was a minimum of about a yard to spare along each side. At the front end of the cabin, the base end of the Thor carried a white bag with the inscription "MANUAL CASE. REMOVE PRIOR TO LAUNCH."

The opposite end of the missile, however, was of much greater interest. Here the IMS (Inertial Measurement System) of the guidance system was being cared for by a white-coated technician from AC Spark Plug, Lavern Urban, whose main job was to ensure that the temperature of the liquid in which the inertial platform's six gyros (three stabilization and three accelerometer) are suspended was constantly maintained within 8° of 165°F. This is accomplished by electrical heating elements cycled to the gyros in appropriate order by temperature-sensing devices. Power comes from the 28V aircraft supply (in flight), or from the motor-generator carried on the missile (before loading and after unloading); also carried on the supporting end-frame, known as the Douglas ring, is an emergency battery. Six orange lights were continuously twinkling on the control box, and on a portable indicator box hung on the side of the dolly, to indicate the heater cycling action throughout the flight.

Above, two in-flight views of the missile, the right-hand photograph showing the Douglas ring attached to the guidance section for accurate temperature control. The power lead from the aircraft electrical supply is connected to the main control panel, above which is mounted the emergency motor-generator

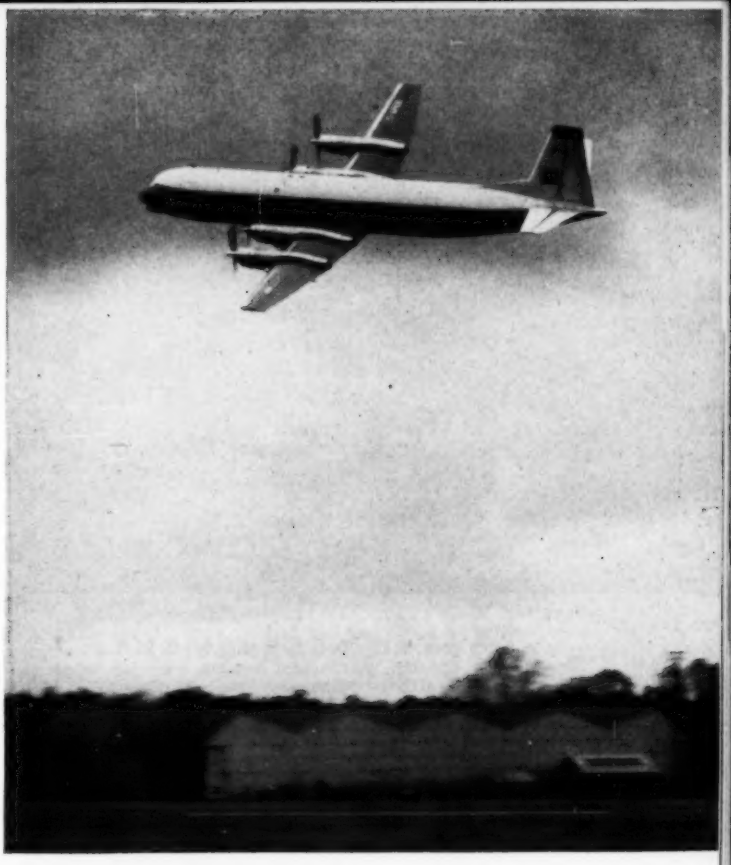
Right, seen at Santa Monica prior to the delivery flight, Col C. A. Peterson, Maj-Gen B. I. Funk, Donald Douglas Jr and Wg Cdr P. L. Hancox

On the journey from Santa Monica to North Luffenham we spent a total of 28hr in the air with the missile, and about 13½hr on the ground during refuelling stops at March AFB (Riverside, California); Dover, where a new crew took over; and Goose (Labrador). For almost all this time Lavern Urban—inevitably dubbed bird-watcher and/or baby-sitter—stayed with, or near, his part of the bird.

Carrying the Thor—which, at about 11,000lb, is a light load for the C-124—seemed to cause few complications in flight operations, other than keeping a careful eye on the use of electrical power (to ensure a steady supply to the guidance section), and being conservative in rates of descent (not exceeding 1,000ft/min) in order to protect the empty tank sections of the missile. As one would have expected of MATS, the operation had become a smooth routine.

At North Luffenham, the fourth and last Thor base to be completed, RAF police dogs, Air Ministry public relations men and a collection of news photographers were among the small crowd on hand to greet us. Col Peterson passed on Gen Funk's plaque to AVM M. H. Dwyer, AOC No 3 Group, for onward transmission, as they say, to Sir Kenneth Cross and, very gingerly, the missile was unloaded on to British soil. Delivery of the 60 RAF Thors was complete.

Mission completed: after arrival and unloading at RAF North Luffenham, the Thor is towed away for inspection at the RIM building. This delivery, made on March 10, completed the initial deployment of Thor IRBMs in the United Kingdom



THE handling impressions contained in this article are those of a BEA pilot with a background of Viscount experience. The author had not flown a Vanguard before he made this assessment on behalf of "Flight," and his reactions to it could consequently be those of any Viscount pilot when first confronted with Vickers' new turboprop. Captain Broom is chairman of the BALPA technical committee, but the views he expresses are his own and do not necessarily represent those of any organization. The Vanguard seen over Vickers' Wisley airfield in the photograph was being flown by the author.

VANGUARD ASSESSMENT

BY CAPTAIN M. W. BROOM

FOR the time of year and the uncertainty of our British weather, one has to be lucky to pick good days a week in advance; nevertheless this I managed to do when arranging with Jock Bryce, chief test pilot of Vickers, to visit Wisley and undertake a flight in a Vanguard. To leap unprepared into an aircraft of this size and complexity for an assessment would take a genius, so it was arranged that I should spend part of one day studying the Vanguard before flying it on part of another.

I do not think it possible to do in five hours what it takes an airline pilot more than a month's course to accomplish, so my comments are from the viewpoint of one converting to the type and flying it for the first time. I arrived at Wisley on a bright sunny day with the wind blowing great guns at 60° to Runway 28, and gusting to over 30kt; so it was as well I was not trying my hand that day. I spent this first afternoon looking round G-APEB, the aircraft which I was later to fly.

This Vanguard differs from production models both in flight-deck layout and structure, but in the main these differences are of detail only. To help my exploration of the flight deck I had the able assistance of T. S. Harris, one of Vickers' test pilots, who was able to explain the various services and systems, where the production machines would differ, and many handling aspects which would have taken a very long time to elicit from the large tome thoughtfully provided by Jock Bryce's assistant "Wilbur" Wright, general factotum, admin. officer and visit organizer.

I had heard of the size of the flight deck; even so it was very pleasant, after working in cramped quarters for so many years, to see the spacious area alloted to the operating crew. Access to the captain's and first officer's seat is from the outside. There is a reasonable amount of head-room so that one does not have to double up to get in; and this arrangement also protects the various controls and switches on the central pedestal and roof panel from being accidentally knocked by a pilot moving in or out of his seat in flight. Though in the pilot's seat you are close up against the central pedestal you are a good arm's length from the other pilot, and the feeling of having plenty of room is increased by the large amount of glass around the flight deck. There is room for the third pilot to enter his seat from either side without interfering with the central pedestal.

"Flight" photograph

The seats themselves seemed comfortable enough, though it requires a prolonged flight for one to find out whether the body starts to ache. The seats are adjustable not only for height and reach but also for rake. There is no head-rest, but the back comes up to shoulder height, and arm-rests incorporating ashtrays fold down from a position beside the back-rest.

The general layout is conventional, but clean and tidy, and on moving about on the flight deck for the first time I was conscious of the lack of snags on which to bang the head, bark the shins and gouge the hands. These are a source of annoyance (especially when one is fatigued) out of all proportion to the actual pain or damage done. The flight deck flooring and walls show the same clean appearance; I can only hope that when the aircraft are in service the same care is taken with day-to-day cleanliness; dust and grime that is only removed at apparently rare intervals cannot be anything but injurious to both crew and equipment.

The entrance to the flight deck is in the centre of the bulkhead, so that from here the whole of the deck is visible. The instrument panels and the central pedestal appear as a large T with the pilots tucked neatly about it. The roof panel is central, and the ground servicing panel is in the roof behind the third pilot's head. The main bank of circuit breakers is to starboard just inside the door, with those for essential services on the side wall beside the first officer. Beside and behind the fourth seat is space for movable paraphenalia such as the aircraft library, brief-cases and the sundry papers which are required these days to get from A to B.

As space is more generous than in smaller flight-decks the instrument panels have a more "open" look, and this makes for easier reading of the right instruments at the right time. Facing each pilot is a standard panel of flight and navigation instruments and the centre panel carries the engine instruments; on the sill panels the captain has the hydraulic system gauges and warning lights; the flowmeters are in the centre; and the first officer watches the fuel contents and r.p.m. gauges for the HP section of the engines.

All radio selectors are on the central pedestal with the autopilot controls in the middle. The "configuration and operation" controls are grouped on the front of the pedestal with the undercarriage and landing/taxying lights behind the first officer's throttles. Normal and emergency flap controls are beside the captain. The roof panel carries the controls and lights for anti-icing, fuel management, air conditioning, starting and electrical supplies, all neatly arranged system by system. There is little that is left to be fitted elsewhere; weather radar units are on the outsides of the sill panels, and the first officer has the emergency manual control for pressurization and the flight-deck temperature control below his nosewheel steering.

When I turned up for my flight there was a sheet of cloud between 3,000ft and 5,000ft, with good visibility below and a surface wind down the runway at about 15kt. A test flight was due on G-APEB to ascertain some fuel consumption figures and at the end of it there would be time and fuel available for me to have a go. The flight was in charge of Vickers test pilot Bill Aston. Another Vickers pilot, Des Addicot, acted as his co-pilot, and Bob Bishop as observer. Also on board were a flock of those white-coated gentlemen who are rarely heard but contribute so much to the success of any new aircraft, and of course *Flight* photographer Macdonald and myself.

[*Continued overleaf*]

"Flight" photograph

The centre cabin of the Vanguard in BEA decor. Not instantly apparent in this wide fuselage is that the seats are six-abreast

VANGUARD ASSESSMENT...

It is always a little confusing to watch experts dealing with a machine about which you yourself know nothing; Bill and Des had three Tynes going before I was able to spot the trick. The starting drill seems very simple, and will be familiar to pilots used to the R-R. Dart. On the starting panel above the first officer's head the master switch is put to START, the individual engine START/RELIGHT switch is held in the START position for about two seconds and HP cock selected OPEN (a warning light shows igniter operation). The starting operation takes place on the HP section of the engine and a special starting "throttle" is provided just in front of the corresponding engine throttle to control the reduced fuel-flow required at starting; when the right r.p.m. are built up the starting "throttle" is operated and the engine picks up to ground-idling r.p.m., and from then on is controlled by the usual power lever.

The method of operating fuel trim seems very good and simple. The HP cock lever is moved beyond the cock OPEN position so that full forward is 100 per cent trim; the quadrant is serrated and marked and the HP lever clicks at each mark. I did not myself handle the levers but it was said that the first officer has to be very careful when setting-up the trim, particularly for take-off. The use of the HP levers for this purpose strikes me as a logical development of the method used on the Dart.

For the first take-off the weight was approximately 120,500lb, giving us a V_2 of 116kt. For this take-off I was in the third pilot's seat, from which position I could quite clearly see what was going on. The communication controls are within fairly easy reach, though the HP levers require a long arm. There is a good all-round view so that the third pilot can keep a reasonable look-out at times when the captain and first officer are busy inside. Take-off and climb were easy and unhurried and lift-off came with plenty of Wisley's runway still available. The climb away at some 2,000ft/min was stable and comfortable with 12,000 r.p.m. and 600°C t.g.t. giving about 190kt. We were very soon at flight level 50, at which the test runs were to be made.

From the first officer's seat I was able to appreciate the excellent view afforded the pilots. The remarkably deep windows give excellent up and down vision even though an arm's length away from the seats; of course, with panels of these dimensions the supports are of robust construction, but I did not find them obstructing the view except at the d.v. panel. This panel on Echo Bravo has a bar across it which for me completely obscured the horizon; however, after the first half-dozen aircraft this is to be modified. All panels are heated by gold film activated by the alternators on Nos 1 and 4 engines and the temperature is thermostatically controlled—a considerable reduction for ground use is automatically brought in by oleo switches. Alcohol spray is provided as a stand-by and all three windscreens have captain-controlled wipers.

During the steady runs we were making Bill Aston was able to amplify my meagre knowledge of the various systems. The anti-icing will be familiar to Viscount pilots with the exception that—though wing anti-icing is by air passed through a heat-exchanger, tapping exhaust gases on Nos 1 and 4 engines—the tail unit anti-icing is electrical, taking its power from either 1a or 4a alternators. Engine anti-icing is by electrically heated pads around the intakes and propeller blade roots, with a hot air tapping from the compressor for the entry guide vanes.

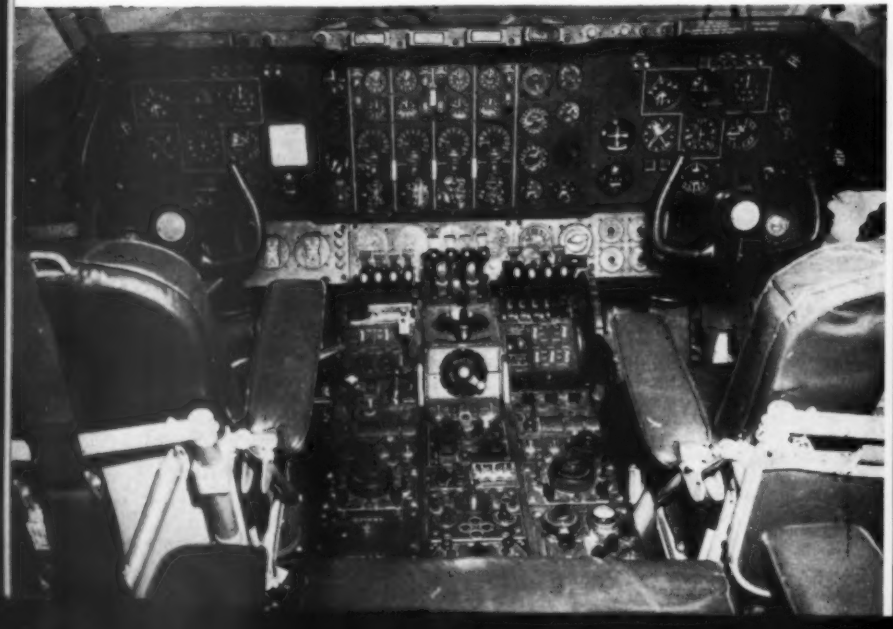
The electrics are described here only in very broad outline; all generation is by frequency-wild alternators (one to each engine) output from which is fed through transformer rectifier units to supply d.c. current to the bus-bars. Each alternator provides its own engine with power for anti-icing. Alternating current is supplied by two main inverters with a stand-by which can take over from either, and an emergency inverter which will supply essential instruments. I was not able to assess the lighting at night nor did we fly directly into bright sunlight to assess how clear the instruments are under such conditions; but I did use the sun visor for a while, and found it easy and effective.

When the fuel tests were completed I was able to take over. There is a large variety of adjustments which can be made to the seat to suit practically any pilot shape. In addition the rudder pedals slide back and forth in unison (it is not possible to move one pedal without moving the other) by pulling a release on the extreme edge of the instrument panel, and the control wheel can be raised or lowered through approximately 3in. by turning a small knob on the control column. The optimum seat position is obtained when the pilot can just see down the glare-shield.

I had been warned that Echo Bravo has non-standard ailerons and rudder, the former being some 20 per cent heavier than the production models and the latter giving odd trimmer positions. I was very pleasantly surprised with the ailerons, however, and found them remarkably light for so large a machine. Very little effort was required to roll from 30° bank one way to 30° the other

"The instrument panels," writes the author, "have an open look and this makes for easy reading of the right instrument at the right time." Left, the main panel and pedestal and right, the roof panels. The ground-servicing panel is uppermost in the photograph

"Flight" photograph



at around 220kt; and later, when I was in the circuit at about 170kt, I found one-handed control quite easy. The elevators I found rather heavy by comparison, and as trim changes noticeably with changes of power and speed I seemed to be somewhat busy on the trimmer. The last-named is very effective; and I expect that, not being used to the aircraft, I was tending to over-trim. I had been informed that the rudder is heavy but effective, but I did not have occasion to need very much even when the critical engine (No 4) was feathered. Apart from manual operation of the rudder trimmer there is also a lever immediately behind which power-drives it, and although only about one division is required to correct a No 4 failure on take-off I think that most pilots will tend to use the power drive most of the time, because it is handier and faster.

Before descending to the circuit I tried the feel on the approach to the stall with undercarriage and full flap. At the weight of the aircraft by that time the stalling speed was down to about 90kt. At 95kt with only a little throttle and on the point of buffet and with the stick shaker going we were losing height only fairly slowly; on the clean stall the buffeting is much more pronounced. Recovery was quite normal and I was left with the impression that if one inadvertently got too close to the stall on approach one could very easily correct the situation.

The cruising power we were using was giving 220-230kt when Bill Aston suddenly feathered No 4. The change of trim was so little that but for the alteration of engine note I would not have known; manœuvrability was not impaired and the speed dropped by only 15kt at most. Engine-stopping in flight is most interesting and simple. Once the HP lever is pulled back to the FEATHER position the appropriate handle on the coaming is operated; if just feathering is required the handle is pushed in, but when the fire drill is carried out the handle is pulled. When the propeller has feathered, the handle is turned to fire the extinguisher bottles; two shots are available. The action of pulling the feathering handle actually performs three functions, because in addition to feathering it also closes the LP cock and cuts off the hydraulics to the engine concerned.

After being away for about 1¼ hours we returned to Wisley, where Bill Aston took over for the circuit and landing—from which he came to a stop in a remarkably short run with only moderate braking and no reverse thrust. We then changed seats and I was "in charge." My first interest after getting my seat adjusted was the nosewheel steering; and as the aircraft moved forward with very little extra power above idling I found that the response to the steering wheel was very good, there being little or no backlash and tight turns being possible without my having to twist my arm off in the process. With this good response very little effort is required to keep straight on take-off and once one is above 95kt the rudders are sufficient to control any swing. I found the unstick required quite a heave, but once off the climb away was most pleasant. The first impression was that not much was happening, this I think being due to the comfortable attitude (neither space-ship nor tree-top style); only reference to the instruments showed that plenty of power was available, and in fact we were at 1,000ft remarkably quickly. The aircraft being so light the power required to hold speed to 180kt while turning down wind kept the propellers on the flight fine-pitch stops even when flap was lowered to 20°. A very marked nose-up change of trim occurs with the lowering of the first 20° of flap but by progressive use of the trimmer I was able to prevent any excessive height change.

Both undercarriage and flaps are hydraulically operated. Supplied with power from a pump on each engine, the system contains a main accumulator and two brake accumulators. The undercarriage selector is behind the first officer's throttles, and in addition to the catch for normal operation, there is a knob on the top which can be turned to give override action for retraction on the ground. In the event of the undercarriage failing to come down, a lever in the floor beside the first officer will mechanically release the UP lock so that the undercarriage (which is of free-fall design) will drop. Pulling this lever also cuts out the nosewheel steering, which gets its power from the undercarriage DOWN lines. There are also visual indicators for the undercarriage DOWN position, though these are not on the flight deck.

Of the Fowler type, the flaps have three positions—20°, 30°, and 40° (take-off, approach and landing)—and the lever beside the captain's right hand is gated to these settings. Just behind the selector is the emergency flap panel which, brought in by a switch, disconnects the main system so that the movement of the emergency flap lever operates a small electro-hydraulic unit to pump out the flaps. The flaps themselves are in several sections, but to guard against asymmetric operation there is a warning light beside the normal flap selector and a mechanical device which disconnects and locks the flaps should a difference of approximately 2° occur between any two sections.

To return to my efforts around the circuit, I found handling quite easy for so large a machine and was able to keep the speed reasonably close to the 130kt approach speed. I made an overshoot off the first approach and there seemed to be very little trim-change with the undercarriage coming up and the flap back to 20°. Next time round I found the approach attitude similar to that of a Viscount, but I was not expecting the ground to appear quite so close on touchdown, with the result that I levelled off a bit too high.

Capt Broom with Vickers test pilot Bill Aston in G-APEB

"Flight" photographs

The first officer's station, access to which is from outside the seat. Note the nosewheel steering and the circuit-breaker panels

However, as we were so light there was a fair amount of float before the actual touchdown, after which reverse thrust soon slowed us down and a touch of brake reduced us to taxying speed. I found the toe-operated brakes very good; and apart from the pressure gauges for normal and emergency use, there are also pressure gauges for the brake accumulators. Beside each pilot there is a hand brake which will give symmetical application but is principally for parking; and behind the parking brake on the captain's side is the change-over lever to cut out the anti-skid system for emergency braking.

Lastly, a subject which is very much in pilots' minds is that of emergency exits. On the Vanguard's flight deck the sliding window panel beside each pilot is large enough for the biggest man and an escape rope is provided below each. For the rest of the aircraft there are the two main doors, with airstairs; a servicing door opposite each main door, with a rope and escape chute; an emergency door at the rear port side, also with rope and chute; and finally two windows on each side which open onto the wings.

What, in brief, are my impressions of the Vanguard after this short flight? The answer is "very favourable." I found the aircraft far easier to handle than I had expected (though it was more than twice as large as anything I had previously flown) and I doubt whether other average pilots will have any handling difficulties. It is definitely a pilot's aircraft and those who eventually operate it should have a pleasant, if busy, working life.

CORRESPONDENCE

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns. The names and addresses of the writers, not for publication in detail, must in all cases accompany letters.

The FAA Report and Decca

YOUR article on the FAA report on Decca does wrong to suggest that one should best forget the argument, and it is sad to see that you are "heartily sick" of having to report on it, since it is only in the columns of journals such as yours that one is likely to see the case for either side fairly stated. There are many pilots, myself included, who are not sorry to see a firm stand made by the FAA, the only disappointment being the weakness of the arguments they appear to have used. May I please be allowed to say what I believe to be some of the basic reasons against the adoption of Decca, and which I should like to have seen the FAA mention?

Decca, being an MF navaid with a good range from the ground wave, and exceedingly high accuracy, is fundamentally much more suited to slow surface navigation than to navigation at high speeds and high altitudes. As speed increases in aviation, high accuracy becomes of much less significance than reliability and ease of operation, whereas the reverse is the case with a trawler steaming at five knots in fog. The trawler skipper needs a high accuracy of fixing and can even stop his ship to set up his Decca. As aircraft altitude increases, the disadvantages of medium frequencies with their associated interference troubles far outweigh the "low-level" advantages. A modern aircraft, in fact, spends very little of its time at a low level, only entering and leaving its terminals which are quite adequately served anyway by beacons, radar and let-down aids.

On the other hand, as aircraft height increases, so do the range and usefulness of VHF navaids, and no pilot will deny that when the radio compass and Decca are both unreliable in bad weather, the steady VOR needle pointing the way is most reassuring. It seems illogical to me that a new navaid, the first "area coverage" aid since Gee, should go back to medium frequencies. In fact I sometimes wonder if aviation has been hustled by skilful salesmanship into buying a navaid basically intended for coastal and estuary shipping, simply because the transmitter stations were already there.

"Area Coverage" is indeed a misnomer when the Flight Log presentation is used. On a selected series of charts, only one or possibly two flight-plan tracks can be shown from departure point to destination, together with a few selected diversions from destination to alternates. For impromptu off-airways flights and *en route* diversions, the Flight Log is of no assistance, having no tracks or distances pre-marked. One has then to fall back on reading the Decometers and plotting and transferring fixes. Whilst coping with an emergency, this is not practical. "Pictorial presentation" is supposed to be one of the advantages of the system. But maps do not always convey the information wanted in the quickest and most simple manner. Your columnist Roger Bacon asserts that "pilots prefer to fly by a map." For a treasure hunt in a Tiger Moth this may be so, but for direct flight from one reporting point to another it is not the case.

I am arguing in these points against the use of Decca as a primary navaid, alternative to VOR. I do not argue against its adoption as a supplementary aid; but, for such, is the weight, space and crew work-load worth while? Transistors may reduce space in the radio rack, but they cannot cut down the extravagant amount of space required for presentation to the pilot. Display head, Decometers and control unit take fully four times the panel area of a VOR presentation, part of which is the ILS meter anyway. Even supposing that the usefulness of the system justifies the weight and space as a secondary system, it cannot possibly justify the extra work-load involved. Apart from the pre-flight setting up, in-flight action requires chain and chart changes, even now a laborious business which must be done at a specific point in space regardless of whatever other job one is involved in, such as taking weathers or watching for other aircraft. When once set up, the Decca presentation has to be constantly monitored by the crew and cross-checked against beacons, ranges, VOR, etc.; and if, ultimately, there arises a discrepancy between the information from other navaids and from Decca, I know of no one who would accept the latter. It is for this reason that plans to arrange a system of lateral separation on airways, using the Decca Flight Log, fills most flying men with apprehension.

The plain fact is that Decca in its present form requires far too much time and skill for its proper operation. Time is never available to spare when things are going wrong and skill and concentration are always reduced by work load, fatigue, bad weather, poor R/T and a hundred other things. I say "in its present form," because I do not know what developments are round the corner to make Decca automatic and foolproof. I hope that eventually a fine aid will emerge which will have eliminated the human factor in its operation, to the level of VOR, and will have increased its reliability to the same standard. But this state of affairs has not yet been reached, and it is therefore not in the best interests of safety at the present time to look upon Decca as a complete alternative to VOR. Let us instead regard it as a promising experiment, still needing much development for use in modern fast aircraft.

Chalfont St Giles, Bucks — R. MITCHELL

[The argument is not whether Decca should replace VOR, which is safeguarded until 1974 and approved by Britain, but whether Decca or Vortac (VOR + DMET) should be adopted as the standard short-range navaid. The operation of Decca Mk 10 and Flight Log should be compared with that of VOR, DMET and a pictorial presentation. The second combination is still an unknown quantity.—Ed.]

AS you so well wrote in your issue of March 4, we are all sick of the Decca/VOR controversy, so I doubt whether anyone will want to hear any more opinions. All the same, here's mine just in case.

When VHF D/F, ADF, SBA, ILS and GCA came into use it was not necessary to ram them down people's throats; they were naturally accepted because they clearly proved their usefulness.

Why, then, does Decca have to fight so hard to be accepted? My own impression, obtained from two years' airline flying with it (Mk 8), is that it deserves a lot of the criticism it gets. My own pet aversion is not so much the complications of keeping it going, and its occasional wanderings, but simply the fact that the Flight Log works on a distorted projection; which is a bit like trying to move about or grab objects while looking through distorting glasses.

When used with the Decometers alone and a lattice chart, it is a good fixing aid; but the Flight Log part, I feel, still needs a lot of improving.

I myself like latitudes and longitudes and true directions, but life is getting more artificial these days, and Decca deserves full marks for pushing it along that way. They can be warmly congratulated on their linguistic achievements which enrich the vocabulary: zones, chains, lanes, keys, masters, slaves, colours, letters, numbers, JIMs, RIPs, WIZs, etc.

Blackpool — AIRLINE CAPTAIN

Air Safety and Hydraulic Fluid

From Sir Miles Thomas, chairman, Monsanto Chemicals Ltd

MAY I cross swords with my old friend the chairman of the Air Registration Board? It is not often that one is able to add to Lord Brabazon's store of aviation knowledge, but I would like to take him up on a point he made in his brilliant speech at the annual livery dinner of the Guild of Air Pilots and Air Navigators.

On the subject of safety in the air, he said, among other things, "I think it is odd that in this year we have not got a non-inflammable hydraulic fluid."

The facts of the matter are that a non-inflammable hydraulic fluid, known as Skydrol 500A, is available and is in wide use throughout the world. Skydrol, made by Monsanto, is mandatory in the Boeing 707, the Douglas DC-8 and the Convair 880, and in their successors, and on this side of the Atlantic it has been made mandatory in the D.H.121 and the Vickers VC10, and is optional in the Vickers Vanguard. In France, all future Caravelles will also be engineered for this non-inflammable fluid.

There is strong circumstantial evidence that the recent incident involving the total loss of a BEA Viscount at London Airport was due to a hydraulic fire, and bearing in mind that the first fire-resistant hydraulic fluid has now been in use for some nine years one can only attribute this type of incident to the reluctance of operators to take advantage of technical progress, rather than to the failure of technical progress itself.

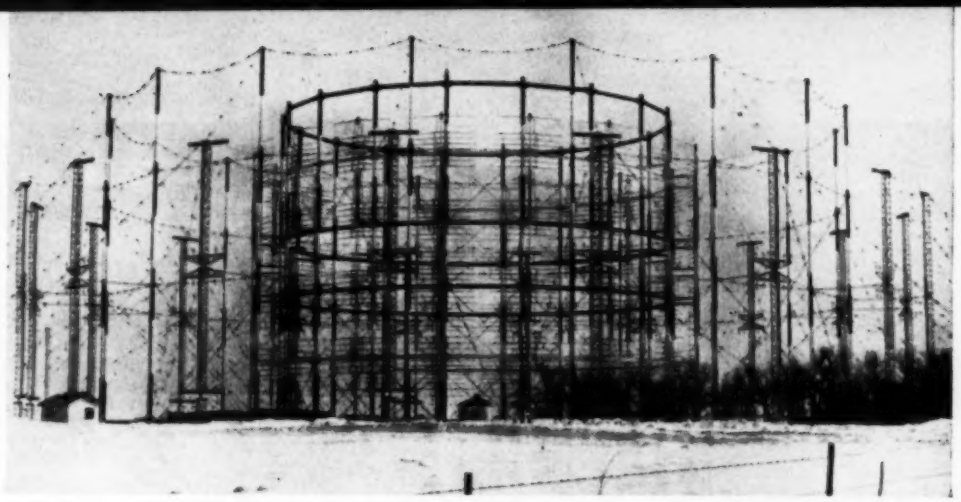
Lord Brabazon, hoping that his voice would be heard all round the world, expressed the view that should there be loss of life in an aeroplane accident resulting from the use of petrol rather than paraffin the operator should be "had up for manslaughter." The same might also be said regarding an operator using an inflammable mineral oil when a non-inflammable hydraulic fluid is available.

London SW1 — MILES THOMAS

[Asked to comment on the opening sentence of Para 4 of Sir Miles Thomas's letter, BEA say that the causes of the accident are still under investigation but that there is "no *prima facie* evidence that the fire was caused by ignition of the fluid in the hydraulic system."—Ed.]

CORRESPONDENCE IN BRIEF

Fg Off Iain S. McNair is writing a history of No 120 Sqn, RAF, and would be grateful for any relevant information and pictures—particularly those dealing with the January 1918 to May 1919 period during which the squadron operated a mail service with D.H.9As and D.H.10s between Hawkinge and Cologne. Fg Off McNair is at RAF Station Kinloss, nr Forres, Morayshire.



The receiving aerial array at Elkhorn, Nebraska, which, with a transmitting array some miles away, forms the new installation by which Strategic Air Command can make contact with any of its bombers, anywhere in the world, from any convenient telephone, radio-equipped road vehicle or aircraft. The system was accepted by SAC on March 4

FLIGHT SYSTEM SURVEY

Radar For Fiumicino and Pershore

THE Italian Air Ministry has ordered a Marconi S.264A/H surveillance radar system for the new Italian international airport at Fiumicino, near Rome. The installation will include the high-power, 500kW 50cm radar modified to provide additional high coverage as well as two separate display systems and a Marconi microwave link. A total of 11 display units will be included. Short-range coverage out to 40 miles will be provided at one centre and long-range coverage to 160 miles at another, the microwave link connecting the two.

Hills and mountains in the area make Rome a difficult location for radar and Marconi point out that their fully coherent MTI will overcome these difficulties. The S.264A also remains effective despite any form of precipitation.

The present order is worth about £177,000 and was obtained through Marconi Italiana S.p.A. It brings the number of Marconi 50cm radars sold to a total of 29.

The MoA, acting for the Royal Radar Establishment, has placed an order for the supply and installation of a Marconi S.264 50kW 50cm surveillance radar and two moving-coil displays and ancillaries to be installed at the RRE airfield at Pershore. It will go into operation in the middle of this year and replace an earlier Type 11 50cm radar. Pershore is surrounded by hilly country and is close to the Birmingham Control Zone.

Simulator For Irish Air Lines

THE contract was signed last week for a Boeing 720 simulator to be made by General Precision Systems Ltd for Irish Air Lines and installed at Dublin. The first Boeing 720 is due to be delivered in November and the simulator should be installed by the end of this year. It will cost about £100,000. This is, incidentally, the first simulator ever to be obtained by Irish Air Lines. Two engineers from the airline are to be trained at the simulator school at Aylesbury, Bucks, by General Precision Systems Ltd, and this company will also assist with the installation of the simulator in Dublin.

Navigation For German G.91s

AN order worth $2,800,000 has been received by Bendix Aviation Corp from the German Ministry of Defence for the supply of Doppler radars and navigation computers to be installed in German Air Force Fiat G.91 light-weight strike fighters. The Doppler is the Bendix type DRA-12 designed originally for civil aircraft but now being extensively applied also to small military aircraft. The fixed, slotted wave-guide aerial is to be mounted in the G.91 in the 1.5in-deep space beneath the air intake duct. The navigation computer is the PHI 3B made by Computing Devices of Canada Ltd, a Bendix affiliate.

The computer calculates bearing and range to base and to any of a number of pre-set reference points using normally sensed air data with corrections supplied by the Doppler radar. A first installation was made in a German air force G.91 in Italy late last year and trials were to begin in January. Trials have been carried out in Switzerland, France and Japan and the PHI has also been specified for Canadian and German F-104Gs. The Doppler/computer combination will provide automatic navigation for the G.91 for strike and reconnaissance flights and also allow the aircraft to be used as a meteorological sonde. Initial information about the plans for this equipment in G.91s and F-104Gs was given in these columns on November 13 and a picture of the PHI 3B appeared on January 29. An initial order worth $1,600,000 for PHIs for German F-104s was placed last year.

Russian Thermo-electric Generator

AN energy conversion group has been formed by the nuclear division of the Martin Co to study thermo-electricity and the direct conversion of heat into electricity. One unit already produced by the division is SNAP (systems of nuclear auxiliary power) wherein heat is provided by the decay of a small amount of tightly sealed radioactive material. The group wanted to study the Russian kerosine-fuelled device used in remote Asian areas to power radios and, after failing to make effective contact with anyone in Russia, eventually located an example in Colnbrook, Bucks. It was purchased for $56.

Weighing 20lb, the device is based on a normal kerosine lamp with thermocouples mounted round the upper portion. When the elements are heated at one end by the lamp, a small amount of electricity flows from the other end. The large metallic fins are intended to dissipate excess heat. One fin is stamped in English "made in USSR."

Incidentally, the international flavour of this venture is heightened by the fact that the head of the energy conversion group is Egyptian-born Dr Mostafa Talaat and two of his assistants are a Chinese, Dr Cheng Shih, and a German, Dr Walter Bienert.

A Russian-made thermo-electric generator, of the type used in remote Asian areas, being examined by members of the nuclear division of the Martin Company. Further details are given above

Straight and Level

A NEW product is announced by Thinx Electronics Ltd—who, you may recall, make the British Air Trumpet, the Hypocrisy Expunger ("Hippo"), the Meeting Simulator, the Reading Simulator, etc.

The new equipment is called SRS, Secrecy Revealer System. Sir Harold Digit-Smith, brilliant chainsmoking boss of Thinx, outlined the purpose of SRS to me over lunch last week at the Air Power Club.

"Frankly, old boy," he said, cramming his menu into the miniaturized reading simulator he always carries about with him, "I think a lot of people are a bit chokker with the secrecy neurosis that afflicts British aviation. Even when our 'Hippo' has expunged hypocrisy from a matter of public interest, we are still confronted by a conspiracy of silence on essential facts."

* * *

He lit two cigarettes. "This is where SRS comes in. The available information, after optional processing by Hippo—yes, it's useful to have Hippo, old boy, the 1960 model—the available information is coded and put on to magnetic tape. Then SRS is programmed. This is quite simple, merely involving preselection of sub-routines held in a six-million-binary-digit cryogenic store. A whole range is available, each clearly placarded—well, anyway, take a look for yourself."

He handed me the SRS brochure, explaining as he lit two more cigarettes that it was a "technical specification" rather than a brochure—brochure was a "stink word."

The list of "sub-routines" was fascinating. Examples: Price obtained by BOAC for used Constellation, Stratocruiser and Argonaut aircraft . . . Ministry levies on Viscount sales . . . UK independent airline traffic and financial statistics . . . Financing arrangements for Olympic Airways' Comet 4Bs . . . Details of BOAC and BEA pool agreements with foreign operators . . . Unpublished Ministry accident reports . . . British aircraft prices and delivery dates, and so on.

I was most impressed, and I asked Sir Harold about price and delivery date. "Well," he said, tearing open a new packet of twenty, "it's not our policy to publish that information, old boy—you know that, surely—but I can tell you that price and delivery are, let's say, highly competitive. But don't quote me, there's a good chap. It's all a bit delicate at the moment—not that we've anything to hide, of course."

● Now that the Government has agreed to aid the financing of new civil aircraft, it's obviously a case of PAY NOW, FLY LATER.

● Probably, by the time you read this, IATA will have agreed on a discount-fare level for propeller airliners on the North Atlantic. So, after three years of wearisome and often quite immoral argument, the jet *v.* propeller fare differential, unless something unexpected happens, is to be applied in the way it always should have been applied, as a propeller-discount.

Looking back through these pages I find that it was in May 1957 that the adoption of the fare differential was first urged. I have never retreated from the view that a differential would check the high capital and depreciation costs of speed competition, direct the attention of airlines and aircraft designers to the cheapest rather than the fastest, develop the mass travel market, fill the aircraft factories without subsidy, etc, etc, bore, bore.

* * *

No one has ever disagreed with all this—they just shrug, like people do when nuclear disarmament is discussed, and say "We agree, but . . ." And they say, sometimes, that a turbofan is the cheapest form of long-range propulsion.

I have sometimes wondered whether I should no longer beweep my outcast state, or trouble deaf airlines with my bootless cries. Then suddenly, I read the following on the leading editorial page of *The Observer*:—

". . . In the longer run the need is to design new aircraft specifically for low-cost operation. For technical reasons they would probably have to be relatively slow, and any development of them would need an IATA agreement to charge less for slower travel. . . . This would encourage the manufacturers to design new and really economical aeroplanes."

What with the *Daily Express* giving front-page splash headline treatment to a London - Paris Vanguard flight, and now *The Observer* giving leading editorial attention to the theory of the fare differential . . .

". . . my state,
Like to the lark at break of day arising
From sullen earth, sings hymns at
heaven's gate."

Heaven's gate? Let's not oversell this thing.

● If an engineer makes a mistake, the consequences are apt to be disastrous, particularly in aviation. If a businessman errs, he may lose a contract or something. But, generally speaking, his mistakes don't kill people.

The engineer's mistakes, he knows full well, are likely to be sensationally revealed in a mass of wreckage. He can rarely get away with a boob. But the businessman often can. His mistakes may reduce his firm's profits—but if it's still a profit, why worry? He can always blame this, that or the other economic circumstance.

But the engineer can't: his mistake is described publicly in unimpeachable technical detail, and he carries the can for it, usually losing his job or his reputation.

Progress always involves some degree of risk. But the businessman will take many, many more risks than the engineer. As a result he is more prone than the engineer to complacency—something rarely found in engineering.

● When I printed the picture of Marty Wilde (March 4) I must confess I suspected that the copy of *Flight* in which he was immersed was a casual acquisition at a Manchester Airport bookstall. But I find that his interest is far from casual, for when in the BBC's "Desert Island Discs" recently Roy Plomley asked him which book he would choose for companionship in his solitude, he replied without any indecision *Jane's All the World's Aircraft*.

● Since restrictions on $ imports were eased nine months ago, 45 American light aircraft have appeared on the British register—an average of five a month. Nice business.

● "I have absolutely nothing against that aeroplane, except prejudice."

ROGER BACON

What is this GI doing hanging around on this underground platform? Did he lose the last train back to base? Is he waiting for the girl he dated at the Palais? Or is he the last and lingering ghost of Rainbow Corner? No — he's just giving scale to a section of an 850ft subterranean causeway at Vandenberg Air Force Base—part of a scheme to shelter missiles and operations and so forth from nuclear attack

Aero Engines 1960

IN our 1960 review of the world's aero engines—written by the Technical Editor—we have been deliberately partial. Engines for missiles and space vehicles are ignored, and small or relatively unimportant aircraft powerplants are dealt with only briefly. This has been done in order that closer than usual attention may be paid to engines of great importance on either technical or commercial grounds. Few powerplants are of such interest—on both counts—as are the new families of what, for want of a universally accepted word, we may call fan engines. Sir Frank Whittle drew them first, Metropolitan-Vickers made them first and Rolls-Royce put them into service first (with the engine whose business end appears behind these words). Gunning engineers in America added fans to existing turbojets, and claimed superiority for their higher by-pass ratios. Now the hubbub is dying away, and the backroom men are generally agreed on what high-subsonic engines should be like. But—like the sponsors of detergents—they will still call them by different names.

GREAT BRITAIN

ALVIS *Alvis Ltd, Coventry.* Notwithstanding unofficial rumours of the company's interest in small gas-turbines—linked with the name of Rolls-Royce—Alvis have made no announcement of such activities, and in the aero-engine field continue to concentrate upon their established reciprocating engines.

Leonides The two principal variants of this highly developed radial are the series 514, in wide service with the Scottish Aviation Twin Pioneer and Hunting President, and the series 531, the first production variant of the uprated long-stroke version.

Still in production, the 514 differs from the later engines in having a stroke of 4.41in and in certain other minor respects. Maximum rated power is 560 b.h.p. at 3,000 r.p.m. with 8lb/sq in boost; the engine is designed to operate on 100-octane fuel, but can accept lower grades after minor modifications. It is basically an improved Leonides 503 and has been subjected to some 6,500hr bench running and 50,000hr in flight. Full ARB and FAA approval has been obtained and the present overhaul life is 1,000 to 1,200hr.

In addition to having an increased stroke, the Leonides 531 incorporates longer pistons and a generally stronger carcase. Equipment includes a Hobson fuel-injection system and either electric or cartridge starting. This mark of Leonides has run some 2,000hr on the bench and 1,200hr in flight, and has ARB approval with an overhaul life of 400 to 600hr.

Leonides Major This powerplant employs two rows each of seven short-stroke Leonides cylinders, giving an overall swept volume of 1,118 cu in. The most important variant is the series 755, for the latest piston-engined Westland Whirlwinds. In these it is installed with the crankshaft at 35° from the horizontal, the drive being transmitted direct to the rotor hub by way of a clutch and cooling fan. Weighing 1,116lb, the 755 has a life rating of 995 b.h.p. at 2,900 r.p.m. with 6.5lb/sq in boost at a height of 3,250ft. Some 7,000hr bench running and many thousands of hours in flight have been logged by 755s; full ARB approval has been obtained, with an overhaul life from 250 to 400hr.

BLACKBURN *Blackburn Engines Ltd, Division of the Hawker Siddeley Group, Brough, East Yorks.* In October 1958 the former Cirrus Engine Division acquired a licence for Turboméca gas turbines. Many of these engines were then in an early state of development, and they were redesigned at Brough and turned into fully equipped aircraft powerplants. The most important from the viewpoint of aircraft propulsion are the free-turbine engines described below. In addition Blackburn have made a number of Palouste air-compressors for helicopters and are in bulk production with this engine for starter trolleys and pods for the Royal Navy and RAF. The single-shaft Artouste drives a large English Electric alternator and other equipment as the AAPP for the Victor, and Blackburn expect future prospects for such units to be good. Regarding piston engines, an order for a further batch of Bombardier 203s was placed recently and Blackburn also overhaul all their piston engines and the many Palouste now in service.

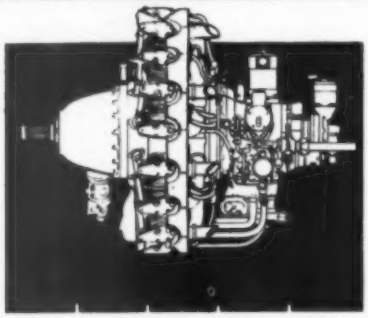
A.129 Although incorporating many components of the Turmo and Artouste, the A.129 gives twice the power with improved efficiency, chiefly by the addition of a two-stage axial compressor and of a second stage to the compressor turbine. The compressor are mounted behind the reduction gearing and other features include variable inlet guide vanes and a tachometer. The combustion chamber is of steel and an integral oil tank can be provided around the frame.

The gas-producer portion was run as a turbine in July 1958, and the complete engine was bench-tested at 840 s.h.p. in August of that year. Development has since been encouraging, and a simulated type-test has already been run. An M.o.A. development contract has been placed for A.129s for the Saunders-Roe Wasp, and much flying has been logged in these aircraft. Blackburn are discussing other applications, and selling price should be under £10,000.

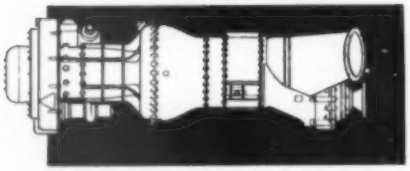
Turmo The Saunders-Roe P.531 Mk 0, a batch of which are being evaluated by the Royal Navy, are powered by a Turmo rated at 400 s.h.p. for a weight of 275lb. These engines have intake and exhaust trunks on either side, and a rear drive.

BRISTOL SIDDELEY *Bristol Siddeley Engines Ltd, Mercury House, 195 Knightsbridge, London SW1.* Since Armstrong Siddeley Motors and Bristol Aero-Engines merged to form Bristol Siddeley Engines in

The engine drawings on the following 20 pages are superimposed on black panels representing a width of 5ft



Alvis Leonides 531 Supercharged and geared nine-cylinder engine. Bore and stroke, both 4.8in; swept volume, 783 cu in; dry weight, 860lb; max rating, 650 h.p. at 3,200 r.p.m. with 8lb/sq in boost at 2,000ft, with consumption of 468-500lb/hr; max cont, 585 h.p. at 3,000 r.p.m. with 6.5lb/sq in boost at 2,500ft, with consumption of 392-418lb/hr.



Blackburn A.129 Mk 3 Turboshaft engine. Compressor with two axial stages followed by single centrifugal stage, annular combustion chamber, two-stage compressor turbine and single-stage power turbine. Max diameter, 20.062in; length as depicted, 62.66in; dry weight, 390lb; max rating, i.s.a., 968 s.h.p.+93lb thrust at 35,000 compressor r.p.m. and 30,000 power-turbine r.p.m. with s.f.c. of 0.681lb/hr/s.h.p.; max cont, 815 s.h.p.+82lb at 34,000/28,100 r.p.m. with s.f.c. of 0.718.

April 1959, the complete organization has shaken itself down, and the two main branches, respectively located in Coventry and Filton, are committed to substantial programmes embracing a wide range of types of prime mover. The following review of the company's aero engines casts no distinction between units of Coventry or Bristol origin.

BE.53 During the past three years the former Bristol engine design staff have applied the major part of their creative energy to a series of double-flow engines which may variously be described as turbofans, by-pass turbojets or ducted-fan engines. In the initial announcement of the BE.53, the first of the family, it was said that this engine can provide both direct lift and thrust, and that its thrust/weight ratio, "higher than that of any existing turbojet," makes possible the design of VTOL and STOL aircraft of high performance. Alternatively, the cold fan air may be used for flap-blowing or for control of the boundary layer over an aeroplane.

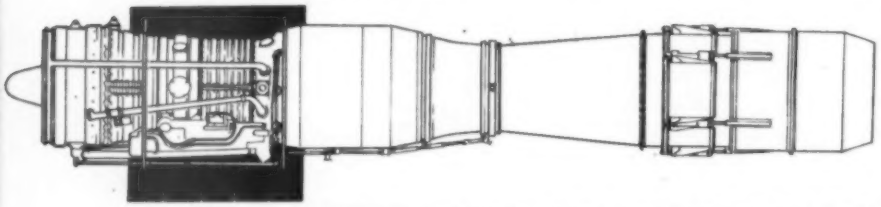
Owing to the fact that the BE.53 is a military engine, few details may yet be published, but one is justified in concluding that it is the engine selected for the Hawker P.1127 VTOL strike/fighter, and that it is therefore in receipt of financial assistance from the USA under the Mutual Weapons Development Programme.

In the drawing (this page) the high-pressure assembly has been shown in solid black. This complete unit is essentially that of the Orpheus turbojet, and it is of great importance to the time-scale of the engine that so critical a component should already be fully developed.

Even the low-pressure system (shown shaded) owes something to other Bristol engines, in particular the Olympus. The by-pass (cold/hot) ratio is very high, and is doubtless similar to that of the BE.58. The cold flow is discharged through lateral ducts, and the propulsive nozzle from each can be turned through any angle between directly downward and directly rearward in order to provide lift or thrust. In a like manner, the hot efflux from the remainder of the engine is ejected in a bifurcated trunk with swivelling nozzles.

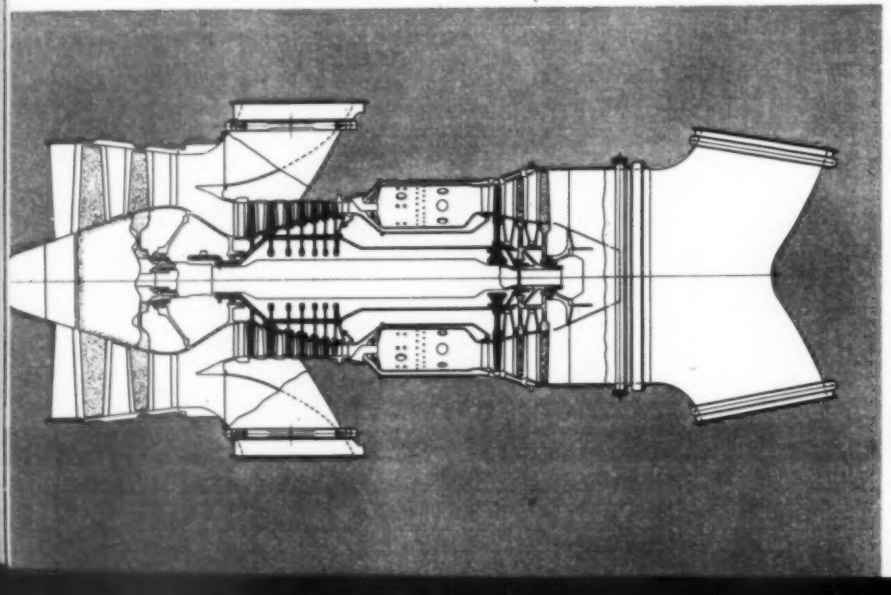
In a recent paper, summarized in our issue of January 1, Dr S. G. Hooker, Bristol Siddeley's technical director (aero) listed six advantages of an engine of this character:

"It can be mounted horizontally in the fuselage of a single-seater aircraft in a conventional manner; the jets can always be directed rearwards, and the aircraft used for conventional take-off and landings; the engine can be started, tested and the machine taxied, with the jets directed horizontally rearwards, obviating problems of ground erosion and debris entering the engine during these phases; for short take-offs (say, 200yd) the aircraft can be accelerated with the jets directed rearwards, and then the nozzles can rapidly be deflected downward, to, say, 60°, when 87 per cent of the thrust of the engine will be given in lift, and half the thrust of the engine will still be available for horizontal acceleration. In such cases the aircraft will clearly sweep its debris behind it well away from its own intakes; even for vertical take-off the engines can first be opened up to full power, and then the nozzles rapidly deflected vertically to give the minimum time for jet erosion and debris to be thrown around; combining, as it does, both lift and thrust in one engine, the BE.53 keeps the maintenance and logistic problems due to dispersal to a minimum." It may also be noted that an aeroplane powered by a BE.53 can operate in a conventional manner when a runway is available and also that the jets may be deflected forward in flight in order to give reverse thrust for very high deceleration, steep descent and short (or vertical) landing. No other aeroplane powerplant combines such qualities as does the BE.53, and it should spawn a prolific family.



Bristol Siddeley Olympus BOI.7R Two-spool turbojet with afterburner. Inspection shows that there is a five-stage low-pressure compressor, seven-stage high-pressure compressor, can-annular combustion chamber with eight flame tubes, single-stage h-p. turbine, single-stage l-p. turbine, fully variable afterburner and multi-position nozzle. Overall intake diameter, 36.55in; length, 295.64in; max rating, 24,000lb; type-tested dry rating, 17,000lb. The weight of the non-reheat engine has been stated to be 3,600lb and the s.f.c. about 0.80.

Bristol Siddeley BE.53 Military lift/thrust turbofan. The diagram below has been published by Bristol Siddeley Engines and, although not directly associated with the BE.53, provides a clear indication of the configuration of this engine. Two-stage low-pressure fan discharging through lateral ducts with swivelling nozzles, seven-stage high-pressure compressor, annular combustion chamber, single-stage high-pressure turbine, two-stage low-pressure turbine, and jet discharge through lateral ducts with swivelling nozzles. Approximate overall diameter, 46.5in (more than 60in over lateral ducts); length, approximately 180in; weight, about 3,000lb; aggregate mass flow, about 300lb/sec with cold/hot ratio of 2; max rating, at least 15,000lb.



Alvis Leonides 531 Supercharged and geared nine-cylinder engine. Bore and stroke, both 4.8in; swept volume, 783 cu in; dry weight, 860lb; max rating, 650 h.p. at 3,200 r.p.m. with 8lb/sq in boost at 2,000ft, with consumption of 468-500lb/hr; max cont, 585 h.p. at 3,000 r.p.m. with 6.5lb/sq in boost at 2,500ft, with consumption of 392-418lb/hr.

BE.58 An example of this commercial engine was exhibited at the 1959 SBAC display. It is essentially a commercial BE.53, and inspection of the display mock-up showed that the original lateral fan ducts had been combined to give a single annular outlet. For airline applications there is no requirement for swivelling nozzles, and accordingly in the BE.58 both the hot and cold flows are taken to propulsive nozzles at the rear. Thrust-reversal can most conveniently be done when all the jet is contained in a single final nozzle. Internally the 58 is probably identical to the 53. Bristol Siddeley have stated that, although it is not an adaptation of an existing unit, "a large number of components . . . are identical or closely similar to those used in early engines which have completed tens of thousands of hours in service." Its development may therefore be expected to progress rapidly.

Under cruising conditions the BE.58's specific consumption is claimed to be "at least 10 per cent lower than the best turbojets," and that under static or climb conditions it shows up even more favourably. Like the BE.53, the thrust/weight ratio is competitive, and the jet noise level should be "some 10 decibels below the best straight jet engine and 15 decibels below the average turbojet." Unlike most engines, the mock-up exhibited at Farnborough carried all its accessories around the upper part of the compressor casing. The equipment included a Dowty fuel system, Rotax low-pressure air starter, twin alternators, Dowty hydraulic pump, fuel/oil heat exchanger and, to port, the oil tank.

BE.61 Rated at some 7,000lb thrust, this middle-sized member of the fan family is specified for the projected Hunting H.107 transport. No details of the engine are available.

BE.72 Bristol Siddeley recently published a diagram showing the improved ground noise-

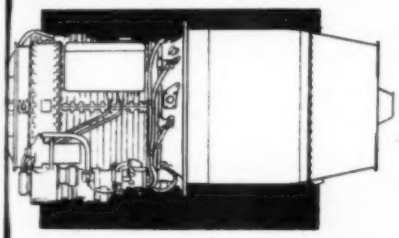
pattern after take-off which would result from re-engining a four-jet airliner with BE.72 ducted-fan engines.

BS.75 An engine of this designation was recently described by the manufacturer as having a specific fuel consumption (sea-level static at maximum thrust) of 0.5. This is the lowest s.f.c. announced for any jet engine. The latest member of the company's ducted-fan family, and the first of the new "BS" designations, it is expected to run in mid-1961. Rating would be about 7,000lb.

Double Mamba In production for ten years, the final version of this unique powerplant is the ASMD.8, doubtless installed in the Gannet AEW.3. It weighs 2,500lb and has a maximum rating of 3,875 e.h.p. with a specific consumption of 0.65.

Olympus Since it first ran in 1950 at a design rating of 9,140lb, this outstanding two-spool turbojet has been doubled in thrust, and is the holder of many records for performance and reliability. It exists in two main versions: the 100-series engines employ compressors with six or seven l-p. and eight h-p. stages, and have been produced in quantity at ratings from 11,000 to 13,500lb for the Vulcan B.1 bomber; and the 200-series, which is described in greater detail later in this account.

In service with RAF Bomber Command since 1957, the engine of the Vulcan B.1s has performed superbly, and is the RAF's most powerful, most efficient and most reliable combat engine, with the highest overhaul life and lowest premature removal rate. It has been officially acknowledged that the handling characteristics of these powerplants surpass those of any other turbojet in the world, particularly at heights above 50,000ft. The first Mark to enter service



Bristol Siddeley Orpheus BOr.12 Single-shaft turbojet. Multi-stage compressor, can-annular combustion chamber and single-stage turbine. Overall diameter, 32.4in; length, 98.325in; dry weight, 1,100lb; max rating, 6,810lb dry. The BOr.12SR gives 8,170lb thrust with simple reheat.

Orpheus BOr.3 Mk 803 (not illustrated). Overall diameter, 32.4in; length, 75.45in; weight, 825lb; max rating, 5,000lb at 10,000 r.p.m. (s.f.c., 1.06); max mass flow and pressure ratio, 84lb/sec and 4.4:1.

was the 101, rated at 11,000lb dry. This engine was succeeded by the Olympus 102, incorporating a zero-stage and rated at 12,000lb. Practically all the Mk 102 engines have now been converted to Mk 104 standard. The take-off rating given in the data panel has only recently been authorized; at the same time the maximum cruise rating was increased to 13,000lb. The engine has a Lucas fuel system and Rotax electric starter, and is equipped for all-weather operation.

In the evolution of the 200-series engines a much higher value of work-per-stage was chosen, in order to achieve a similar pressure-ratio with three fewer compressor stages. At the same time the mass flow has been increased by something like 50 per cent, and the resulting unit is substantially more powerful than its predecessors, for roughly the same cost and weight. The Olympus 200 went into production in 1956 as the powerplant of the Vulcan B.2. Rated at 16,000lb dry, these engines were quickly superseded by the Mk 201, which has since been manufactured in quantity at 17,000lb and is performing excellently in production aircraft. Bristol Siddeley believe that it has a thrust/weight ratio better than that of any other large type-tested turbojet. The existence of the BOl.21 may also be mentioned, but no details may be given.

In its ultimate form the Olympus is being developed with an afterburner as the powerplant of the supersonic Vickers/English Electric TSR.2. Several forms of reheat Olympus have been developed. A straightforward conversion of the Olympus 201 has a rating of 24,000lb, but a development fitted with Bristol Siddeley/Solar fully-variable reheat has a maximum thrust of 33,000lb. Doubtless the TSR.2 will have two engines of approximately this power, conferring upon it an outstanding thrust/weight ratio.

Orpheus Planned as a simple and reliable successor to such engines as the Nene, the Orpheus first ran in December 1954 and flew in the prototype Gnat the following year at an initial rating of 3,285lb. Owing to its intrinsic merit, and to the paucity of competition, it has now become virtually a world standard in fighters, trainers, transports and tactical attack machines. Several hundred first-generation Orpheus have so far been produced, all conforming approximately to the specification given for the Mk 803.

The principal members of this family are the Mk 100 for the Gnat Trainers, the Mk 701 for the Gnat fighters, the 801 and 803 in the Fiat G.91 (these engines are licence-built by Fiat in Italy, Klöckner-Humboldt-Deutz in West Germany and Hindustan in India), and the 805 in the Fuji T1A. Similar engines have been supplied for aircraft designed in Yugoslavia, France and the USA. Special mention should be made of the Mk 100, which for the Gnat T.1 has been derated to 4,230lb, redesigned in detail and provided with anti-icing, to fit it for its arduous duties. Another variant is a transport version (the BOr.3/5 Mk 810, rated at 5,100lb and incorporating bleed-air anti-icing and additional accessories).

In order to provide a powerplant of increased capacity better matched advanced strike aircraft, Bristol Siddeley have developed the BOr.12, under the auspices of the Mutual Weapons Development Programme. From its inception the Orpheus 12 has performed admirably. It completed its type-test last October at the full rating given in the data panel, with a fuel consumption 2 per cent below the design figure. It also stripped excellently after a 24hr special-category test with reheat at 8,000lb thrust, and flight testing in a Sabre up to heights over 50,000ft has shown startling improvements over the design targets (at the tropopause, thrust was more than 7 per cent up, and s.f.c. 11 per cent down).

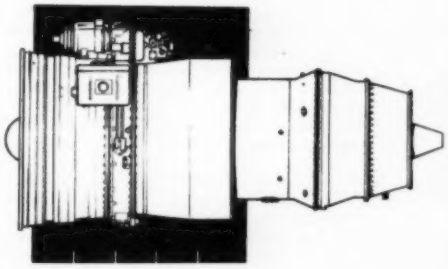
The BOr.12SR has a reheat system of a special simplified pattern, intended principally to provide increased thrust for operations from poor airfields. Aircraft designed to use it are in various stages of development in France, India and Spain. There is also a non-reheat commercial variant, fitted with a two-position nozzle which in the closed position permits the take-off rating to be raised to 7,200lb and at full area lowers the cruising consumption. Weight would be some 1,220lb with full airline equipment.

Proteus This highly developed turboprop remains the most powerful propeller engine in airline service. Hours flown on scheduled routes are well over one million. First to enter service was the 3,900 e.h.p. Proteus 705, which built up its overhaul life more rapidly than any other aero engine has ever done, reaching 2,000hr in under two years. It was followed in December 1957 by the 755 of 4,160 e.h.p., which has been succeeded by the 761 (4,175 e.h.p. and reduced specific consumption), the 762 (4,350 e.h.p. for hot and high airfields) and the 765. The latter is used by Cubana and (in 255 military form with water injection) by the RAF, and for a weight of 2,900lb has a rating of 4,445 e.h.p. (s.f.c., 0.6). In December 1958 it was announced that the Proteus 770 would succeed the 765, with 3 per cent lower specific consumption and a take-off power of 4,615 e.h.p. Other Proteus are employed in the propulsion of naval craft and in ground power generation.

Sapphire Only very few Sapphires remain to be constructed, but well over 2,000 have been delivered from Brockworth in both 100 and 200 series. The former version, rated at from 8,000 to 8,500lb, is fitted to the Hunter 2 and 5, and Javelins 1 to 6. The 200-series engines, rated at 11,000lb dry, power the Javelin 7 and Victor B.1. The ASSa.7R, incorporating a simple reheat system giving a maximum rating of 12,230lb, remains in production for the Javelin FAW.8 and 9.

Viper Conceived as a 1,640lb-thrust short-life turbojet, the Viper has now been developed to give more than double this thrust. Still the most numerous, the first-generation Vipers are typified by the Mk 101, weighing 525lb, giving a dry thrust of 1,750lb, and fitted to the Hunting Jet Provost T.3. In one of these machines a Viper 101 completed 500hr of intensive flying, including over 100hr at take-off thrust, and was finally stripped excellently after a further 250hr on the bench (with no replacement of parts at any time). Similar engines have been employed in many British and foreign aircraft, target drones and missiles.

Virtually a scaled-down Sapphire, the 2,460lb Viper ASV.11 handles a greater mass flow within the same diameter. Engines of this type are in production for the Jindivik 3 and Macchi MB.326. From it are being evolved the ASV.12 (2,700lb thrust, achieved by very minor improvements), the ASV.20 (575lb weight,

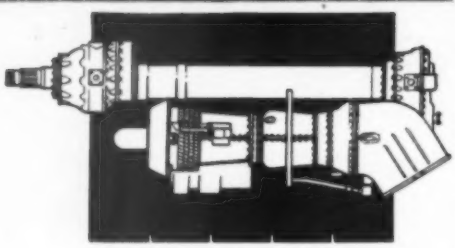


Bristol Siddeley BE.58 Commercial turbofan. Two-stage fan, seven-stage compressor, annular combustion chamber, single-stage high-pressure turbine and two-stage low-pressure turbine. Front-frame diameter, 46.5in; basic length, 123in; dry weight, 2,600lb; max rating, 14,500lb with s.f.c. of 0.572; cruise rating, at 36,000ft at 500kt, 3,750lb with s.f.c. of 0.8.

3,240lb thrust), and the P.209, which weighs 593lb and will be rated at from 3,000 to 3,830lb dry with s.f.c. correspondingly varying from 0.845 up to 0.975.

Ramjets Originally Bristol Aero-Engines acquired experience in the field of supersonic ramjets with the development of the Thor engine to provide cruise propulsion for the Bloodhound missile. Such units are now exceedingly reliable, and in service in great quantity. With a diameter of 15.75in they generate a maximum theoretical thrust horsepower of over 100,000 at M3. The BRJ.801, with a diameter of 18in, may be almost twice as powerful.

These missile engines have been mentioned as an introduction to Bristol Siddeley's exploration of the field of propulsive systems for supersonic airliners. They have demonstrated the calculated advantages of a transport powered by a combination of turbojets and ramjets. Assuming a still-air range of 4,000 n.m. and a cruising L/D of 7.5 at M3, the turbo-ramjet machine has a payload of 8.6 per cent of the gross weight, more than twice



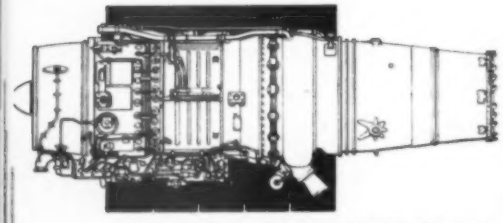
D.H. Gnome P.1000 Free-turbine turboprop. Ten-stage compressor with variable-incidence inlet guide vanes and first three stators, annular combustion chamber with 16 burners, two-stage compressor turbine, independent single-stage power turbine driving through rear reduction gear, high-speed top shaft and front reduction gear to suit propeller speeds from 1,245 to 1,550 r.p.m. Overall length, 87.3in; height, 31.55in; width, 17in; dry weight, with starter and accessories, 555lb; mass flow, 12.4lb/sec; pressure ratio, 8.3:1; max rating (5 min.), 1,000 s.h.p.+144lb thrust at 26,260 r.p.m. (20,000 power-turbine r.p.m.) with s.f.c. of 0.669lb/hr/s.h.p.; recommended cruise, 800 s.h.p.+120lb at 25,120/17,000 r.p.m. with s.f.c. of 0.728; the P.1200 will have corresponding ratings of 1,150 and 900 s.h.p. with s.f.c. of 0.657 and 0.71.

that of the aircraft with the next best system of propulsion (pure turbojet). Bristol Siddeley are also paying great attention to air-breathing engines intended for Mach numbers considerably greater than 3, and have published design studies for hypersonic ramjets of both the internal and external variety.

D.H. ENGINES *The de Havilland Engine Co Ltd, Leavesden, Herts.* In our 1959 review we opened with the words "Since our last engine review issue the character of this company has changed markedly." Today this is even more true, since the worth of D.H. Holdings has been purchased by the Hawker Siddeley Group, making D.H. Engines the only wholly owned powerplant firm of one of the two giant groups of the realigned British aircraft industry.

Substantial business is likely to accrue from the company's purchase of a licence to manufacture and develop the T58 turboshaft engine from International General Electric, and the resulting Gnome is described above. Various types of Gyron Junior turbojet are under development, or nearing production. Manufacture of centrifugal turbojets has finished, but spares are being made for the thousands in service. Development of Gipsy piston engines is concentrated on the Major, in production as the Mk 140 for Army Skeeters and available in Mk 215 turbosupercharged form. Small batches are in production, together with a few Queen 30 Mk 2s (overhaul life 1,600 hr on trial to 1,800) and Queen 70 Mk 2s (overhaul life 1,000hr, on trial to 1,200). No aircraft-propulsion applications remain for the company's extensive range of rocket motors, although the Spectre 4 is in production for the RDS.15 a.t.o. unit for the Victor, the Super Sprite a.t.o. pack is nearing the end of its production run for the Valiant and a number of RDS.33 Double Spectre powerplants have been produced for the first type of Avro Blue Steel.

Registered HQ are at Leavesden, near Watford, where are located the Business, Production and Industrial Products divisions. At Stag Lane, Edgware, are based the Engineering and Rocket divisions, Nuclear Power Group and the development and production test of piston engines. The flight test installation department is at Hatfield, together with the Halford gas-dynamics laboratory and the development and production beds for gas turbines and rockets. In Soho, London, are various DOs and the technical HQ of the Nuclear Power Group. Total employees are approximately 5,000.



D.H. Gyron Junior DGJ.2 Mk 101 Single-shaft turbojet. Eight-stage compressor with variable inlet guide vanes and first stator stage, annular combustion chamber with 13 upstream burners, annular air-bleed manifold for flap-blowing, and two-stage turbine. Intake diameter, 26.4in; overall diameter at bleed manifold, 34.4in; overall length as depicted, 128.7in; max rating, 7,100lb; other details classified.

Gyron Junior By scaling the Gyron turbojet to a two-fifths output the first family of Juniors was evolved in 1954 as Project Study 43. The new engine started life at a rating of 7,000lb, and the first prototype DGJ.1 ran in August 1955. It enabled Blackburn to design the NA.39, and has since been developed in that aircraft and in a Canberra, while an Ashton-hung DGJ.1A pod is investigating NA.39 intake de-icing. The first interim production engines (DGJ.2 Mk 101) are now on test. These undoubtedly incorporate a zero-stage, like the more advanced PS.50 family described below.

A feature of these engines is the large bleed manifold around the combustion chamber, from which a huge airflow may be supplied for flap blowing and supercirculation (which in the NA.39 is extensive). A Rotax l-p. air starter is fitted, and the Dowty fuel system incorporates a single-circuit spill burner gallery, hydraulic all-speed governor and mechanical top-speed governor trimmed by the j.p.t. control. The front end is heated by bleed-air and a Lucas pump serves the fuel-operated inlet-guide-vane actuators. Air-cooled turbine blading is probably employed.

By adding a zero-stage and two rows of variable stators (controlled by a function generator supplied with an r.p.m. signal) the company have evolved the PS.50 family. Under development since October 1957, this engine is matched with a high-augmentation afterburner and fully variable nozzle to provide a propulsion system for flight at Mach numbers greater than 2.5. As the DGJ.10R it has an important application as the powerplant of the Bristol Type 188, which will fly this year.

This application is reflected in the engine's special constructional materials and comprehensive control system. Equipment includes a Rotax pneumatic starter, Dowty two-circuit spill-burner fuel system, Delaney Gallay fuel-cooled oil cooler, port and starboard power take-offs, twin drive faces for hydraulic pumps, and a Hobson-Microjet control for the afterburner and variable nozzle. The latter can be convergent, or convergent/parallel with reheat, or convergent/divergent at the design (high supersonic) flight Mach number. At Luton Napier have installed a pair of T.188 powerplants in a Javelin, which after some delay is about to fly. Bench trials are in hand under simulated high-altitude supersonic conditions at the NGTE. Mention may also be made of the DGJ.20, designated PS.50 Phase 2, with a bell-mouthed intake casing.

Gnome Since 1951 D.H. Engines have exchanged technical information with International General Electric, and in February 1958 it was announced that a licence had been purchased to manufacture and develop the T58 (q.v.) as the Gnome. This gave the British firm a tremendous advantage in the market for shaft turbines in the 1,000 h.p. class. Unlike its competitors, of which there were then several in Britain, the T58 was already highly developed, having run some 8,500hr in the USA and flown in helicopters.

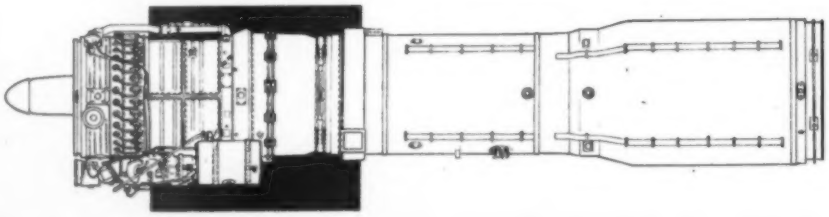
D.H. Engines are developing the Gnome in both fixed-wing (P-series) and helicopter (H) versions. Owing to their similarity to the T58, the latter are more advanced in development. A number of Gnome H.1000s were manufactured last year, and the first went on to the bench on June 5. Although roughly equivalent to the T58-GE-6, these engines are entirely British, and are fitted with a Lucas fuel-metering system working in conjunction with an electric computer (around the intake) developed by D.H. Propellers. Flight testing started in August in a Whirlwind and the Gnome-P.531 Wasp flew a few days ago.

Current Gnome H.1000 applications include the Whirlwind (new aircraft and conversions), Wasp and Agusta 101G; and the Gnome would also be fitted to the Vertol 107 or Sikorsky S-61 for BEA or other European customers. Production engines of DGJ.2 rating differ from their predecessors in that the computer is airframe-mounted, while the electric throttle actuator is relocated on the left-hand side. The bulk of current production is for RAF Whirlwinds, in which the engine will enter service early next year at a 1hr rating of 1,000 s.h.p. Production engines on 25hr special-category tests have indicated a potential exceeding this level, and early development is planned to take advantage of the temperature and gas-generator r.p.m. in hand to uprate the engine, initially to 1,175 and ultimately to more than 1,400 s.h.p.

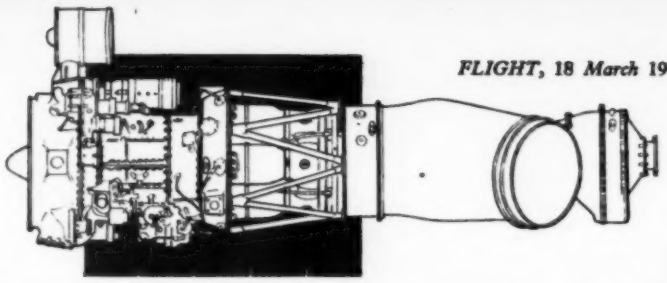
Turboprop Gnomes are now being assembled and bench testing of the P.1000 will shortly begin. In these engines the existing primary gearbox drives an upper high-speed shaft housed in a casing from which the power section is hung. The powerplant mounting points are located on the rear primary box and front secondary epicyclic box. The latter will provide a final drive to a three-blade DH reversing propeller specially designed for the engine. The configuration overcomes the difficulty of driving a propeller from a rear free-turbine, and also allows the complete power section to be readily detached, while leaving the gearboxes and propeller undisturbed. In multi-engine STOL aircraft—such as the Intégral—the primary gearbox can be linked by layshafts to maintain the drive to all propellers in the event of engine failure.

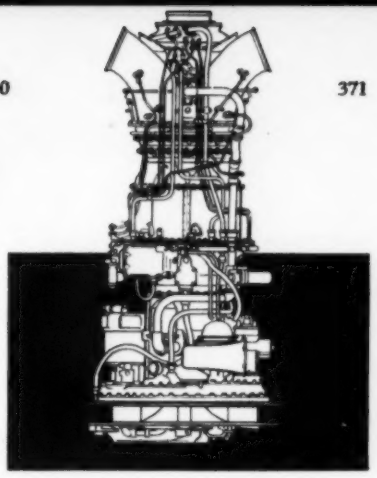
The first important application of the P.1000 is in the de Havilland D.H.123 twin-engine transport. Flight testing is scheduled to begin early next year, probably using a DC-3. During 1961 the engine is scheduled to enter production and complete its type certification at the P.1200 rating of 1,200 s.h.p. D.H. have also designed the Coupled Gnome, initially rated at 2,200 s.h.p., in which two power sections drive through freewheels to a single high-speed shaft.

Overhaul life of the first Gnomes to enter



D.H. Gyron Junior DGJ.10R Supersonic turbojet with high-augmentation afterburner. Configuration as for DGJ.2, with deletion of bleed manifold and addition of fully-variable afterburner and nozzle system; overall diameter of engine, 32.3in; diameter of afterburner, 36in; length, 191in without intake bullet; max rating, 10,000lb (14,000lb with reheat).





Napier Eland 229A Commercial turboshaft engine. Ten-stage compressor, six combustion chambers, three-stage turbine and hydraulic coupling to rear drive. Overall diameter, 36in; height over oil-cooler blowers, 51in; length as depicted, 135in; dry weight, without rear drive, 1,500lb; max rating (2½ min), 3,150 s.h.p. at 12,500 r.p.m.; one-hour rating, 2,600 s.h.p. at 12,500 r.p.m.; max continuous, 2,400 s.h.p. at 12,500 r.p.m. Corresponding estimated ratings for the E.211 (production Westminster engine) are 3,500, 2,850 and 2,650 s.h.p.

Napier Gazelle NGa.13 (right) Military free-turbine turboshaft engine. Eleven-stage compressor, six combustion chambers, two-stage compressor turbine and single-stage free power turbine. Overall diameter (intake casting), 33.5in; overall height, 70in; equipped dry weight, 865lb; max rating, 1,800 s.h.p. (5-min limit) at 20,400 compressor r.p.m. with s.f.c. of 0.664, or 1,450 s.h.p. (one-hour) at 19,500 compressor r.p.m. with s.f.c. of 0.703. Note: this engine can be mounted at any angle and is shown in the vertical position.

service—H.1000s and P.1000s—will be 400hr. This should rise to 1,000hr by the end of 1962, and the ultimate goal is 3,000hr. No prices have been quoted, but one might expect an equipped H.1000 to cost rather less than £15,000.

NAPIER *D. Napier & Son Ltd, Acton, London, W3.* This member of the English Electric Group (but not of the new aircraft giant including English Electric's Aviation Division) has not produced a new engine design for a considerable period. It is relevant to record the report published by the London *Daily Telegraph* last month to the effect that "talks have been in progress for Rolls-Royce to take part in development of the two current aircraft engines designed and built by D. Napier & Son . . .", although neither firm can comment on this suggestion. Production of Elands and Gazelles is in hand at East Lancashire Road, Liverpool. The main design offices and commercial HQ are at Acton; a variety of test beds, including an all-angle one for the Gazelle, are at Park Royal and the Flight Development Establishment is at Luton. Other major aeronautical products include liquid-propellant rockets, HTP tip-drive booster systems for helicopters, Napiercast hot parts for engines and other equipment, and Spraymat electric de-icing.

Eland The only large British single-shaft engine, the Eland has been developed in three major versions, all incorporating the same power section. These sub-types are described below.

Turboprop For aeroplanes the Eland is fitted with a two-stage reduction gear (of advanced design described in our issue of November 27), which takes the drive through at a ratio of 10.25 or 14:1 to the four-blade de Havilland propeller. The standard engine in service is the Eland 504. Allegheny Airlines are re-equipping with Eland-powered Convair-liners, five conversions and ten new Canadair 540s. The airline have bought 15 Elands and have an option on 30, the conversions being done by AiResearch. Overhaul time should reach 1,000hr by the end of this year. Other 504s are being supplied to Canadair for the ten CL-66 transports for the RCAF, and the first Canadair-built aircraft flew on January 7. Total hours on February 11 amounted to 25,259, including 10,000 in flight. The basic type-test took place in February 1958 and the Eland was the first turboprop to be fully certificated by the FAA. Differing from the 504 only in having first-stage turbine blading of N.105, the Eland 508 has the maximum continuous rating raised to 2,930 s.h.p. or 3,190 e.h.p.

Helicopter For the Westland Westminster the basic power section is extended to the rear, to drive through a remote hydraulic clutch and an aircraft-mounted primary gearbox to a secondary box in which the power from the two engines is transmitted to the single rotor. Each engine carries a drum oil cooler and a Plannair fan above its intake. The hydraulic clutch has been cleared at 3,500 s.h.p. and the all-speed governing has proved so effective that this will be the power of the production E.211 engine. A speed difference of one per cent corresponds to some 1,500 s.h.p., and accordingly the synchronizing forces match the r.p.m. of the two powerplants closely.

Rotodyne The prototype Rotodyne has conducted all its flying on a pair of Eland NEl.3s. These are basically turboprop 504s with an added rear hydraulic coupling and drive to an auxiliary compressor feeding air to the rotor pressure-jets. A month ago running time amounted to 1,243hr, including 304 in the aircraft on the ground and 226 in flight.

Gazelle Conceived as an any-attitude engine for helicopters, this free-turbine unit is now fully developed for operation under arduous conditions in all parts of the world and is in production as the NGa.2 (installed vertically in the Bristol 192) and the NGa.13 (installed at 35° in the Westland Wessex). Yet another version may be employed horizontally in the Westland Wiltshire. Bristol engines differ from Wessex units in having "mirror image" turbine blading to drive in the opposite direction, and are cleared at a high emergency power to give the 192 good single-engine performance. A full type test was run last November, and the civil Gazelle 500 was recently awarded special category ARB approval.

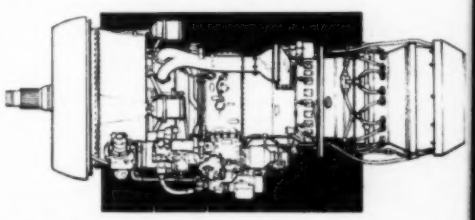
ROLLASON *Rollason Aircraft and Engines Ltd, Croydon Airport, Surrey.* By arrangement with M Roger Druine and the Popular Flying Association, Rollason are producing the Ardem 4CO2 flat-four for installation in Turbulents. The basic engine has a swept volume of 72.62 cu in, a compression ratio of 6.6 and a dry weight (including propeller and exhaust stubs) of 133lb. Maximum rating is 30.7 h.p. at 3,000 r.p.m., with a consumption of 14pt of 80-octane petrol per hour. The company have sold about 30, each costing £272 10s. Rollason have also made six 4CO2-FH units, which develop 40 h.p., weigh 13lb less and cost £367 10s.

ROLLS-ROYCE *Rolls-Royce Ltd, Derby.* No other company has acquired such experience in so many fields of flight propulsion as has the great Derby firm whose name is synonymous with engineering excellence. Although Rolls-Royce ramifications embrace nuclear power, oil engines, rail traction, cars, fighting vehicles and spaceflight, by far the greater part of the company's energies are devoted to gas turbines of advanced design for all types of aircraft. These units have been outstandingly successful, and many thousands of Derwent and Nene centrifugal turbojets, Avon axials and Dart turboprops are now in use in every part of the world.

Employees of the Aero Engine division remain at about 34,000, out of a company total of 42,000. Military Avon production is handled by the Scottish factories, which also produce spares for older engines. Other establishments are those at Ilkeston and Mountsorrel, both near Derby, the Research and Development Centre at Barnoldswick, Lancs, and the Flight Development Establishment at Hucknall, Notts. The company also make the twin-chamber rocket engine for the Blue Streak LRBM—assisted by a Rocketdyne licence—and manage the Ministry of Aviation's Rocket Test Establishment at Spadeadam, Cumberland, where the powerplant is now on test.

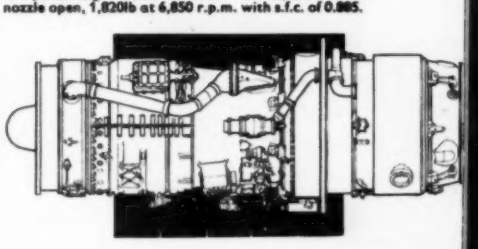
Avon (Military) In 1950 the first-generation Avon became the first axial gas turbine to go into production in the British Commonwealth. These engines have a 12-stage compressor, eight separate combustion chambers, a two-stage turbine, and electric or cartridge starting, and later models incorporate bleed-air anti-icing. Dry ratings run from 6,500 to 8,100lb and the afterburning versions give a thrust of about 9,500lb. Such engines are still being built by Commonwealth Aircraft Corp (Australia) and have been manufactured by FN (Belgium) and SFA (Sweden).

In 1953 bulk deliveries began on the first of the 200-series second-generation Avons. These have a 15-stage compressor, and intro-



Rolls-Royce Tyne RTy.1 Mk 506 Commercial two-spool turboprop. Six-stage low-pressure compressor, nine-stage high-pressure compressor, annular combustion chamber with ten flame tubes, single-stage high-pressure turbine and three-stage low-pressure turbine. External diameter over intake, 35.3in; overall installational envelope diameter, 40.5in; length as depicted, 110.154in; dry weight, 2,220lb with all equipment; max rating, 4,500 s.h.p. (4,985 e.h.p.) at 15,250 r.p.m.; corresponding mass flow and pressure ratio, 46lb/sec and 13:1; typical cruising rating, 425 m.p.h. at 25,000ft, standard day, 2,455 s.h.p. (2,685 e.h.p.) with s.f.c. of 0.405lb/hr/e.h.p.

Rolls-Royce Avon RA.29 Mk 527 Commercial turbojet. Sixteen-stage compressor, annular combustion chamber with eight flame tubes, three-stage turbine and two-position sound-suppressing nozzle. Overall diameter, 39in; length, 125.975in; dry weight, 3,327lb (including oil and fuel systems, controls and electrics); max rating, 11,700lb at 8,000 r.p.m.; corresponding mass flow and pressure ratio, 173lb/sec and 9.63:1 max cont, 9,810lb with s.f.c. of 0.749; low-percentage cruise at M0.74 at 35,000ft, with nozzle open, 1,820lb at 6,850 r.p.m. with s.f.c. of 0.885.



duced a can-annular combustion chamber which allowed the airflow to rise yet reduced the engine diameter. The first of these engines, used in Valiants, and all recent Hunters, are rated at 10,000lb dry, but current production is concentrated upon later engines incorporating air-cooled turbine blading, which has permitted a valuable rise in turbine-entry temperature without sacrificing blade life. Many hundreds of engines with air-cooled blades are now in service, giving Rolls-Royce service experience ahead of any other manufacturer in the world. Typical of these engines is the RA.24, rated at 11,250lb dry and considerably more with reheat. A special variant equipped for flap-blowing is used in the Scimitar and Etendard 4M. Advanced Avons are licence-built by FN and SFA. Total production exceeds 6,600, and the engine has been chosen by 17 air forces throughout the world. The latest version is the RB.146 (*q.v.*).

Avon (Civil) By adding a zero-stage to the compressor and a third stage to the turbine, Rolls-Royce have evolved an economical, cool-running Avon tailored to airline operations. These engines bear the Ministry of Aviation rating of RA.29, and the basic RA.29/1 went into production in the autumn of 1957 as the Mk 522 (Caravelle), 524 (Comet 4) and 525 (Comet 4B). Features of these engines include a compressor rotor with ten stages of aluminium alloy and six of titanium, stator blading of aluminium alloy changing in the final five stages to titanium or (Mk 525) steel, an electric starter and a bleed from the compressor delivery for anti-icing and cabin pressurization.

Scheduled services began with BOAC in October 1958, at an overhaul life of 1,000hr (an unprecedented starting figure). This time has now climbed to 1,800hr, and reliability has been outstanding. During the first year in passenger service, in which some 100,000hr were flown by Comets and Caravelles, the unscheduled-overhaul rate was one per 28,500hr. Scheduled time is now approximately 250,000hr and there has yet to be an involuntary shut-down as the result of a main engine failure in passenger service.

Minimum thrust of the RA.29/1 is 10,500lb. Rolls-Royce have now begun deliveries of the RA.29/3 (page 371), which has a variable-area nozzle and is fitted to the Caravelle 3. During the coming summer deliveries will begin of the RA.29/6 Mk 531, for the Caravelle 6, incorporating a "00" stage; this engine has an average thrust of 12,500lb, and was fully approved by the ARB in January. Weighing 3,491lb, it achieves a specific consumption of 0.762 at full power.

Conway Carrying into practice a principle conceived by Sir Frank Whittle, the Conway was the first large by-pass turbojet to be built, in which excess delivery from an oversized low-pressure compressor is by-passed around the hot central part of the engine to a propelling nozzle at the rear. The first Conway was constructed in January 1950, but today's engines stem from a redesigned powerplant laid out in the summer of 1956. Two versions were planned, one being a relatively bare unit for the Victor B.2 bomber and the other being an airline powerplant for the Boeing 707-420 family and Douglas DC-8. The latter engines are designed for nacelle installation, and carry on their carcase a forest of accessories, including a fuel/air starter and (Boeing engine) bleed-air turbocompressor for cabin pressurization. The airline engines are installed with full reverse and silencing nozzle.

Only 25 months from the start of design a production Conway Mk 509 was shipped to Douglas, and numerous powerplants have now been delivered for both DC-8s and 707s. In the case of the latter aircraft the Mk 508 is supplied as a powerplant, complete with cowling, reverser and suppressor. Scheduled operations with both types of aircraft are about to begin. Unlike the civil Avon, the by-pass engine operates at a high turbine temperature, and the high-pressure turbine blading is air-cooled. Materials used in the compressor are aluminium alloy (first six low-pressure), titanium (final l-p and first seven h-p) and steel (two final h-p). The by-pass duct is butt-welded with great precision in thin titanium sheet.

Distinguished by a new front end, the next development stage is the RCo.15, rated at 19,000lb at 9,895 r.p.m. with an s.f.c. of 0.701. Running since January, these engines have longer blades at the intake to handle a mass flow of 295lb/sec, and are due to be delivered late this year. Representing an even greater advance is the RCo.42, which, although it retains the original high-pressure assembly, has an entirely new low-pressure system handling a mass flow of 363lb/sec with double the former by-pass ratio (0.3 to 0.6). The resulting diameter of 45in is no embarrassment to a nacelle-mounted engine and, as the Mk 540, this superb powerplant is due for delivery early in 1962 for the Vickers-Armstrongs VC10. Minimum rating is to be 20,250lb at 9,955 r.p.m., with s.f.c. of 0.636.

Dart During its seven years in world-wide airline service, this single shaft turboprop has flown well over 10m hr, including over 9m in Viscounts. One major production version, the RDa.6 in service with KLM, has an overhaul life of 2,600hr, greater than that achieved by any other aero engine.

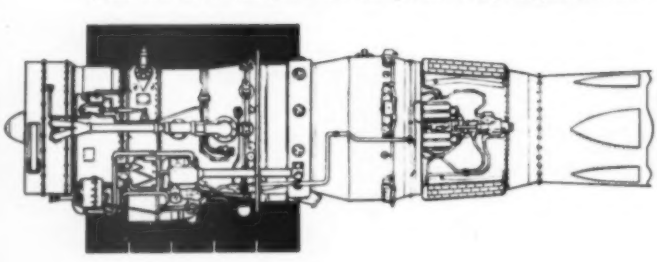
Most Darts are of the RDa.6 rating, of 1,742 e.h.p., and the RDa.7, with a three-stage turbine, which in most Viscounts is limited to 1,800 s.h.p. and in other applications is rated at 1,910 s.h.p. or 2,105 e.h.p. Hundreds of these engines are being delivered for Viscounts, Argosies, Friendships, Heralds, Avro 748s and Gulfstreams, and a military variant is in production for the Breguet Alizé.

By incorporating air-cooled turbine blading, together with a redesigned compressor handling a greater mass-flow, Rolls-Royce have evolved an uprated Dart for both civil and military applications. The civil RDa.10 passed a type-test at 2,400 s.h.p. dry (2,660 e.h.p.) two years ago, and last month a batch of RDa.10/1 engines was purchased for the Japanese YS-11 transport, each rated at 2,750 s.h.p. with water/methanol injection. Even greater powers have been achieved by the military engine; early in 1958 one passed a 25hr test at a wet rating of 3,200 s.h.p., and take-off ratings up to 4,000 h.p. are envisaged.

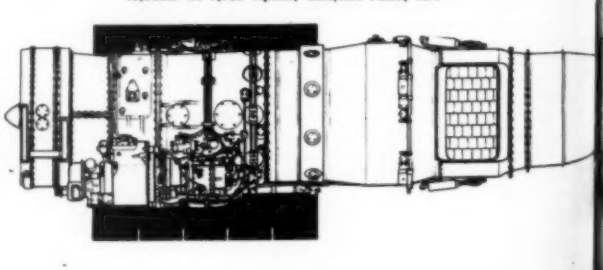
Tyne Into this second-generation turboprop is incorporated all the immense experience which Rolls-Royce have obtained with the Dart and with high-pressure, high-temperature military turbojets. Initially projected to have a rating of some 2,500 h.p., the Tyne is now in the 6,000 h.p. class, and its development is expected to continue up to the region of 10,000 h.p. It has no propeller-driving rival.

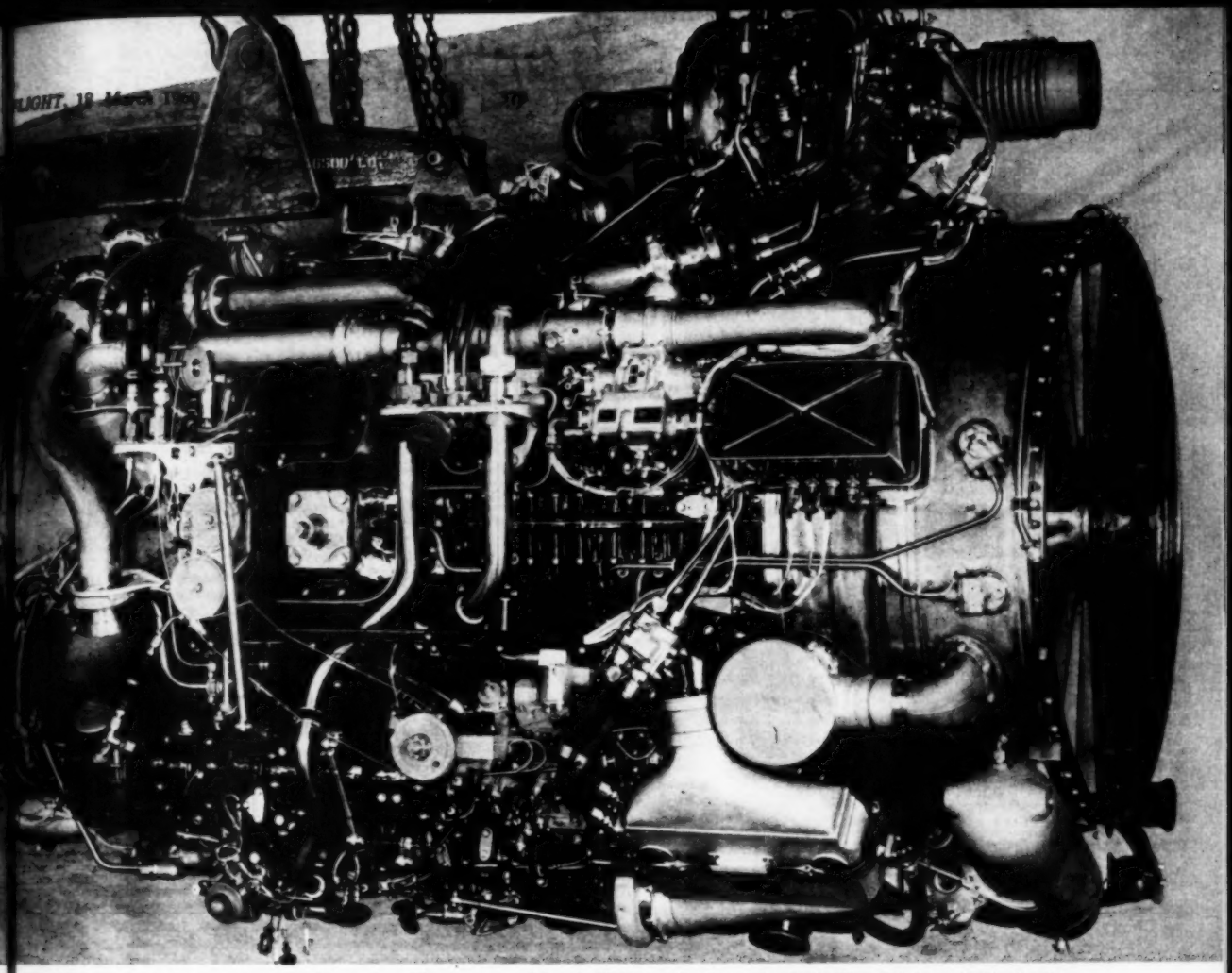
Pride of place in this issue is accorded the Rolls-Roy… jet, … Boeing 707 Intercontinentals and Douglas DC-8s, … ion is

Rolls-Royce RB.163 Commercial by-pass turbojet. Four-stage fan/compressor, twelve-stage high-pressure compressor, can-annular combustion system with nine flame tubes, two-stage high-pressure turbine, two-stage low-pressure turbine, reverser and silencer. Overall diameter, 34.8in; length to reverser front flange, 110.05in; equipped dry weight, 2,315lb; max rating (5min guaranteed minimum), 9,850lb with s.f.c. of 0.578; mass flow and pressure ratio, 202lb/sec and 16:1.



Rolls-Royce RB.141/11 Commercial by-pass turbojet. Multi-stage low-pressure fan/compressor, multi-stage high-pressure compressor, can-annular combustion chamber with nine flame tubes, independent high-pressure and low-pressure turbines, and reverser. Overall carcase diameter, 39.4in; length to reverser front flange, 114.5in; equipped dry weight, 3,560lb; max rating (guaranteed minimum), 15,000lb at 9,750 r.p.m.; cold/hot ratio, 0.7.





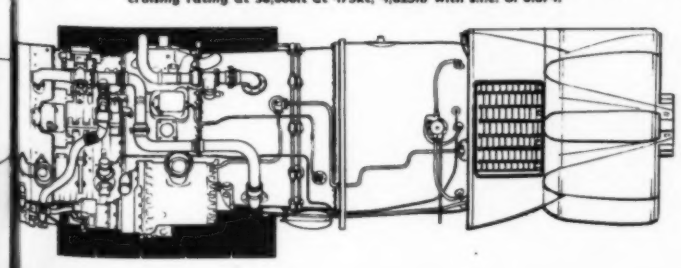
Rolls-Royce jet, which is now entering passenger-carrying service. The most powerful and efficient airline jet engine in the West, it is in production for the DC-8s, and version is being developed for the Vickers-Armstrongs VC10. The engine illustrated is a Mk 508, of 18,000lb average thrust, for a Boeing 707

In order to obtain maximum efficiency, Rolls-Royce have employed air-cooled turbine blading and a two-spool compressor, and the component efficiencies are exceedingly high. D.H. Propellers have designed the four-blade propeller, and the control system incorporates β-regime in reverse thrust. An annular intake surrounds the two-stage epicyclic reduction gear. Around the outside of the intake duct is an annular oil tank, and on its rear face are disposed the four anti-vibration mounting points.

Bench running started in April 1955 and flight development in June the following year. Numerous engines are now flying in Vanguards, CL-44s and an Ambassador, and the RTy.1 Mk 506 (for BEA Vanguards) and RTy.11 Mk 512 (for TCA Vanguards) have full ARB approval. The more powerful RTy.12 or 14 is in production as the Mk 515 engine for the Canadair CL-44, and a closely related unit will be manufactured for the Short Britannic and Transall C.160. Canadair give the cost of the RTy.14 as $175,000, and Lockheed price the set of four engines and D.H. propellers needed for the GL.207 Super Herclues at $906,000. Both firms note that the Stage 4 Tyne will give 6,445 e.h.p. in 1962.

At the time of writing the two applications requiring the greatest development effort are the Fairey Rotodyne and the Breguet 1150 Atlantic. The Rotodyne engine will have an auxiliary compressor and hydraulic coupling very similar to those currently used, but the Tyne will provide much greater power, the probable rating being 5,250 s.h.p. For the Atlantic a special military variant is being developed with a wet rating of over 6,000 s.h.p.

Rolls-Royce Conway RCo.12 Commercial by-pass turbojet. Seven-stage low-pressure compressor, nine-stage high-pressure compressor, can-annular combustion chamber with ten flame tubes, single-stage high-pressure turbine and two-stage low-pressure turbine. Overall carcase diameter, 42.2in; length to reverser front flange, 9in; equipped dry weight, 4,542lb; max rating 18,000lb (average), 17,500lb (guaranteed minimum) at r.p.m. with s.f.c. of 0.725; corresponding mass flow and pressure ratio are 282lb/sec and 14:1; typical cruising rating at 36,000ft at 475kt, 4,625lb with s.f.c. of 0.874.



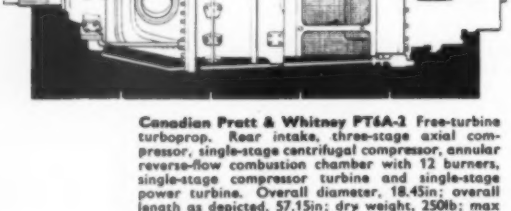
RB.108 Typifying the company's first thoughts in the field of jet lift engines, this small turbojet was first announced in November 1955. Its characteristic features are extremely high thrust/weight ratio; rapid response to fluctuating power demands; the ability to provide a large flow of bleed air to jet-control nozzles at the extremities of the aircraft; and exceedingly simple accessory systems. In the Short SC.1, the four lift engines are mounted in a pair of twin packages, each of which is normally disposed substantially vertical but which can be tilted 30° fore or aft for acceleration and deceleration. An additional RB.108 is fitted in the tail of the SC.1, to provide normal forward propulsion.

RB.141 During 1956 Rolls-Royce appreciated that they could design a family of transport engines which would surpass in performance any which could be designed elsewhere. Essential contributing factors were the company's experience with by-pass engines, two-spool engines of high pressure-ratio, engines with air-cooled turbine rotor blading and high flame temperatures, and with exhaust systems

involving the optimum mixing of hot and cold flows, a reverser and silencer. Rolls-Royce have chosen the modest by-pass ratio of 0.7 in order to achieve low s.f.c. with light weight, while preserving a small engine diameter to give low nacelle drag.

The first engine of the new family to be planned was the RB.141, and its design began three years ago. Initially the 141 was intended as the powerplant of the Airco D.H.121, but when this airliner was "shrunk" in the paper stage the engine had to be scaled as well (see RB.163). It is matched to the Caravelle 7, and is also well suited to several other aircraft. After extensive component and rig testing the first 141 started running last December, and three are now on the bench. Delivery of certificated engines is scheduled for early 1962.

RB.145 Described and illustrated in our last Aero Engines issue (March 20, 1959), this small turbojet is a derivation of the RB.108, with a zero-stage and full equipment for all-weather propulsion of piloted aircraft. Dry rating is 2,750lb and an afterburning variant is available for supersonic applications.



Canadian Pratt & Whitney PT6A-2 Free-turbine turboprop. Rear intake, three-stage axial compressor, single-stage centrifugal compressor, annular reverse-flow combustion chamber with 12 burners, single-stage compressor turbine and single-stage power turbine. Overall diameter, 18.45in; overall length as depicted, 57.15in; dry weight, 250lb; max take-off rating, 500 e.h.p. (460 s.h.p.) at propeller speed of 2,350 r.p.m. with s.f.c. of 0.69; rated power, 400 e.h.p. at propeller speed of 2,100 r.p.m. with s.f.c. of 0.74.

PT6B-2 Turboshaft engine. Weight, 225lb; max rating, 500 s.h.p. with s.f.c. of 0.71 at output speed of 6,800 r.p.m.; rated power, 400 s.h.p. with s.f.c. of 0.75 at output speed of 6,000 r.p.m.

Thor E. Stephenson, president of Canadian P & W, demonstrates that the PT6A-2 will have less than one-seventh the frontal area of the Wasp—of roughly the same power

RB.146 Revealed at the 1959 SBAC Exhibition, the RB.146 is the latest and most powerful variant of the military Avon. It corresponds approximately to the commercial RA.29, since it incorporates a zero-stage conferring greater mass flow and pressure ratio. As a result of its higher turbine-entry temperature it is more powerful than the airline unit, the dry rating being 13,220lb. From the outset the 146 has been designed for flight at over M2, and with an afterburner is going into production for advanced versions of the English Electric Lightning and Saab Draken. Dassault have announced that export versions of the Mirage III are now being offered powered by this engine.

RB.153 From the context of some reports it may be that the RB.153 is similar to a project illustrated in a lecture by a Rolls-Royce engineer in which an engine of RB.145 character is used to provide either a jet for forward propulsion or a flow of hot gas to drive a vertical-lift turbofan running on an axis at 90° to that of the engine itself. Such an engine would suit the VTOL combat aircraft by the German Sudflug Group, and may be jointly developed by Rolls-Royce and MAN (*q.v.*). On the other hand, reports published in France state that the 153 is a relatively conventional tilting turbojet of high thrust/weight ratio, scaled to give a rating of 4,960lb. In the section dealing with MAN (p. 377-8) it is noted that six such engines may be used in these German projects.

RB.163 In last week's issue we were able to reveal the basic characteristics of this new airline powerplant. Essentially a scaled-down RB.141, the 163 is sized to the propulsive requirements of the three-engined Airco D.H.121. In its development Rolls-Royce are bringing to bear all their experience in the evolution of advanced airline engines, and it is their confident belief that the 163 cannot be matched by any other powerplant in prospect.

In the D.H.121 it is installed as an integrated package, complete with a hot/cold mixer, reverser and a silencer, the latter handling the combined mixed flows. Compared with current Conways, the work-split between the low- and high-pressure compressors has been altered, the latter now handling a higher proportion of the total. As a result the h-p. turbine has two stages, and the lower pressure of the by-pass flow enables perfect mixing to be achieved, with a gain of some 2 per cent in s.f.c. It is likely that the RB.163 will start bench-running this year, and certificated production engines are to be available at the end of 1962. An unofficial report claims that Allison wish to licence-produce a version designated ARB.963

AUSTRALIA

CAC *Commonwealth Aircraft Corporation, Melbourne.* Outlines of CAC's piston and turbojet programmes were given in our issue views of July 26, 1957 and March 20, 19[59]. After delivering 114 Rolls-Royce Nenes for Vampires made by D.H. Australia, CAC started manufacture of the Rolls-Royce Avon in 195[3]. Some 200 Avons were ordered; rather less than half were for Canberra B.20s of the RAAF, the majority being fighter units for the CA.27 Sabre. These, and the later Canberra engines, are 7,500lb all-weather units essentially similar to the RA.7 Production has virtually ceased.

BELGIUM

FN *Fabrique Nationale d'Armes de Guerre, Herstal.* The Turbojet Department of this renowned armaments company was founded in 1949. Initially it was charged with the manufacture of turbojets of Rolls-Royce design for the Benelux air forces. These engines comprised 1,000 Derwent RD.8s for Gloster Meteors, 300 Avon RA.7s (Mks 113, 115, 12[1] and 121) for Hunter 4s and 300 Avon 203s for Hunter 6s.

Currently the department is repairing and overhauling these engines, and the Orenda 1[4] of the Belgian CF-100 Mk 5 interceptor. Similar contracts have been placed for the Turboméca Marborés of Belgian Magister. FN are certain to share in the international NATO programmes for the F-104 Starfighter and Bréguet 1150 Atlantic. The engines for these aircraft, respectively the GE J79 and Rolls-Royce Tyne, are said by FN to be planned for manufacture "within a European framework . . . with which this department will be closely concerned".

CANADA

CANADIAN PRATT & WHITNEY *Canadian Pratt & Whitney Aircraft Co, Ltd., Longueuil, Quebec.* In recent years this company's main production has consisted of 1,5[50] h.p. Wright Cyclone R-1820-82s for CS2F-[1] Trackers. Considerable repair and overhaul of Pratt & Whitney piston engines is also undertaken. Turbine work began with the company taking a major share in the design of the J[1]1 described in the section dealing with the parent firm. They have now developed the engine described below.

PT6 First shaft-turbine designed in Canada, this powerplant has been aimed at the business and private field above 200 installed h.p., while retaining "the usability and economics of the Wasp Junior." Its configuration resembles the Lycoming engines, with the difference that the power section is back-to-front, the annular intake and accessories being at the rear and the exhaust issuing from below the propeller reduction gear. Features include fixed geometry; an integral oil tank between the intake and accessory sections; a Hamilton Standard JFC-50 automatic control system; drives for a starter/generator, vacuum and hydraulic pumps, tachometer and power take-off; and ready sub-division into four major sections for overhaul.

Both helicopter and turboprop versions

being developed. The latter, designated PT6A-2, has a compound-epicyclic reduction gear giving a final drive at up to 2,350 r.p.m. The turboshaft PT6B-2 has only a single stage of gearing, to give an output at up to 6,800 r.p.m. It is suited to a variety of helicopters, VTOL platforms and of surface applications, and can run continuously at any angle from 45° nose-down to 110° nose-up. Water injection can maintain full power to 95°F. The inlet arrangement permits tractor and pusher installations to be selected at will but in most turboprops there will be a single scoop inlet above the cowling. Design studies began in October 1958, detail design began early in 1959 and bench testing started last autumn. No price has yet been quoted, but the company expect the PT6 to cost about $30 per horsepower. Prototype flight engines are to be made available next year.

ORENDA *Orenda Engines Ltd, Toronto.* Starting from scratch at the end of World War 2, Orenda Engines (originally the engine division of A. V. Roe Canada) have built up an organization which has demonstrated its ability to carry to fruition major engine programmes. After producing the small Chinook turbojet the company designed the Orenda, roughly similar to the earliest Avons. This fine engine was in production from 1952 to 1958, total deliveries amounting to 3,794. The final variants were the Orenda 11 for the CF-100 Mk 5 and the Orenda 14 for the Sabre 6, both rated at 7,500lb dry.

In September 1953, the company started the development of Project Study 13, a turbojet intended for the propulsion of a future supersonic all-weather fighter for the RCAF (the Avro Arrow Mk 2). Maturing as the Iroquois, this engine is potentially the most powerful turbojet in the Commonwealth. Considerable bench and flight development took place, but when the Arrow programme was terminated in February 1959, work on the Iroquois ceased also.

J79 Cessation of the Orenda and Iroquois programmes dealt Orenda a shattering blow. Somewhat reduced in size, the company are now preparing to manufacture an advanced version of the J79, under licence from International General Electric, for the Canadair CL-90 (Canadian-built Lockheed F-104). About 300 powerplants will be required, Orenda's subcontract from Canadair being valued at $80m.

CZECHOSLOVAKIA

OMNIPOL *Omnipol, Prague 3, Washingtonova 11 (National agency for aero-engines).* In our reviews of April 9, 1954, May 11, 1956, July 26, 1957 and March 20, 1959, we gave brief details of the chief Czech engines. The Walter Minor 4-III and 6-III are giving way to the M-332 and 337 with direct injection. These are all inverted in-line units, but the Praga Doris B is a flat-six of recent design. Also in limited production are the VK-1A turbojet and ASh-82T radial of Russian design.

FRANCE

DASSAULT *Avions Marcel Dassault, 7 Quai Carnot, Saint-Cloud.* This very successful non-nationalized airframe manufacturer devoted some effort during the past six years to small turbojets initially based upon the Bristol Siddeley Viper. The work culminated in the R.7 Farandole, rated at 3,100lb dry. All such work has now been abandoned and the company say that their energies are concentrated upon other enterprises. Dassault never really intended to become an engine firm, but the possibility of achieving a head-start—via the Viper—into this field when the French Government favoured the twin-engined light attack machine was too strong to resist. In the event, the Orpheus won for the single-engined formula, and Dassault lost out, along with SNECMA, Hispano-Suiza and Turboméca (*q.v.*).

DRUINE *Avions Roger Druine, Paris 16.* Basing his work on the Porsche/Volkswagen air-cooled flat-four, the late M Druine developed a powerplant for his Turbulent light aircraft under the name of Ardem 4 CO2. Brief descriptions of two versions are given in the section dealing with Rollason (Great Britain).

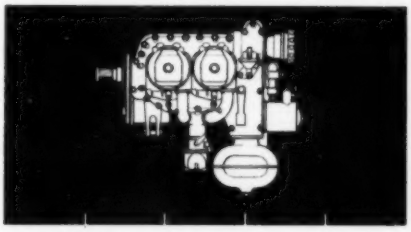
HISPANO-SUIZA *Société d'Exploitation des Matérials Hispano-Suiza, Rue du Capitaine Guynemer, Bois-Colombes, Seine.* Production of large centrifugal turbojets of basically Rolls-Royce design or derivation has now ceased. Over 1,600 were delivered, and repair and overhaul for the air forces of France, Israel and India remain major commitments. The company's own small axial of 3,300lb thrust found no application (see remarks under Dassault), and the only new aero-engine work is the manufacture, under sub-contract to SEPR, of the production Type 841 rocket packages for Mirage IIIs.

NORD *Nord-Aviation SNCA, 12 Rue Beranger, Chatillon Sous Bagneux Seine.* Since 1950 the Arsenal, and its successor Nord-Aviation, have been engaged upon the development of a wide range of ramjets. Largest is that fitted to the company's own turbo-ramjet Griffon aircraft. In the course of extensive flight testing, experimental engines have been fired to well over 66,000ft, reaching Mach numbers from subsonic values up to more than 3.5. The most important is that described below.

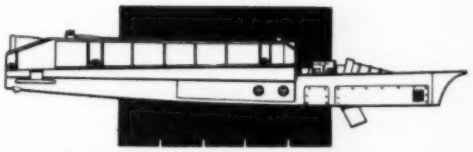
Sirius 1 As the powerplant of the Nord-Aviation Narval surface-to-air missile, the Sirius has reached an advanced state of development and been manufactured in some quantity. It has a circular cross-section, with a fixed centrebody housing the ram-air turbopump and control system. Around the rear portion of this centrebody are disposed inner and outer rings of fuel injectors, immediately downstream of which are the gutter-type flameholders. Air for the turbopump enters at a direct pitot intake, turns inwards through 90° in a cascade, drives the turbine at 15,000 r.p.m. and exits through a discharge system on the other side. Nord envisage the Sirius as the forerunner of a range of powerplants for missiles and (auxiliary thrust) aeroplanes.

POTEZ *Société des Avions et Moteurs Henry Potez, 46 Avenue Kleber, Paris 16.* Showing commendable enthusiasm in what Britain appears to regard as a trivial and diminishing market, Potez' efforts to develop their range of small piston engines are reaping commercial success. The principal products are the 4D and 4E series. These engines are manufactured in the new plant at Argenteuil, together with helicopter transmissions and other mechanisms.

4D All engines in this series are inverted four-in-lines. The most important variant is the 4D.34, powerplant of the Nord 3400 for the French Army. The engine has a supercharger, injection carburettor, electric starter and direct drive to a hydraulic c-p. propeller. Swept volume is 354 cu in, compression ratio 7.63 and dry weight 408lb; maximum rating is 260 h.p. at 2,550 r.p.m., using 100/130 grade fuel, with a specific consumption of 0.49lb/hr/h.p. A related unit is the 240 h.p. 4D.32, equipped for aerobatics as the powerplant of the Nord 3202 trainer. At the start of this year Potez began the series-production of 376 of both types against a Government contract awarded at the end of 1958.



Potez 4E-02 Light piston engine. Flat-four, ungeared, unsupercharged. Width, 30.1in; height, 24.8in; length, 27.1in; dry weight, 203lb; bore, 4.33in; stroke, 3.543in; swept volume, 209 cu in; max power, 105 h.p. The engine has been certificated at 96 h.p. at 2,530 r.p.m. with s.f.c. of 0.5.

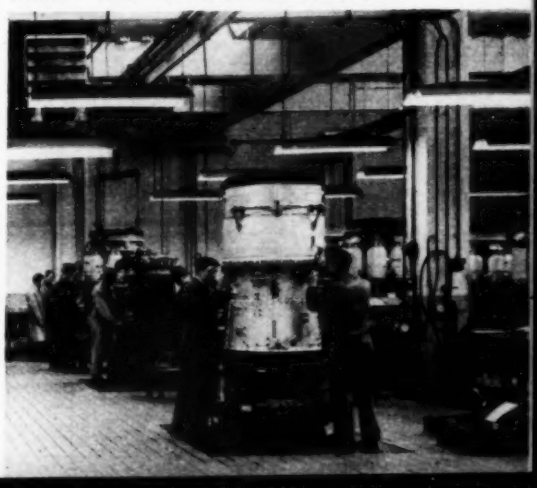


SEPR 841 Demountable rocket package. Oxidant tank, fixed thrust chamber, turbopump group (shaft-driven by turbojet) and control system. Width, 45in; height, 25.5in; length, 128.2in; weight of package complete, 452lb (190lb bare motor); thrust levels at sea level, 1,654 or 3,374lb with s.f.c. of 0.0048lb/sec/lb; thrust at 52,459ft, 3,704lb with s.f.c. of 0.00435.

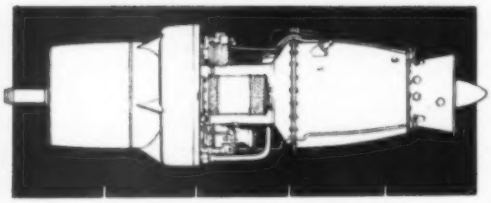
4E During the past three years Potez have evolved this flat-four to suit a wide range of light aircraft. The compression ratio is 7, yet the 4E operates on 80-octane fuel and has a competitive power/weight ratio. Equipment includes an electric starter and d.c. generator. At present 4Es are being run at a rating of 105 h.p. Known as the 4E-02, these units incorporate minor modifications. The engine was revealed at the 1959 Paris Salon, and has now run 600hr on the ground and in a Jodel Ambassadeur preparatory to delivery before the end of 1960. Certification at 90 h.p. was achieved last November. Production is likely to run at about 50 engines monthly, and a substantial proportion of the initial batches—reportedly to a total of 400 engines—may be supplied to Cessna in the USA. According to *Aviation Week* the price in America may be about $1,600.

SEPR *Société d'Etude de la Propulsion par Réaction, 37 Rue des Acacias, Paris.* Founded in 1944, this nationalized group is

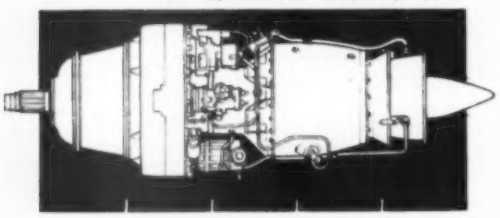
Rolls-Royce Avon 100s and 200s being assembled by FN (Belgium) for Benelux Hunters. Some 600 have been delivered



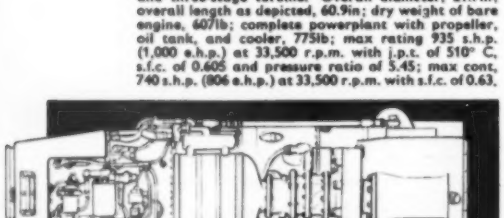
the largest in Europe engaged in the field of rocket propulsion. Its facilities at Villejuif, Argenteuil, Melun-Villaroche and Istres have a covered area of 121,230 sq ft, and employees number 750, a high proportion of whom are graduate engineers. The shareholders include large firms in the French aircraft, metallurgical and chemical industries, and SEPR is one of the six companies behind SEREB (the French ballistic-missile organization).



Turboméca Astazou Single-shaft turboprop. Single-stage axial compressor followed by single-stage centrifugal compressor, annular combustion chamber and three-stage turbine. Overall diameter, 18.1in; length, 57in (71.2in from tip of spinner to tip of tailcone); dry weight of bare engine, 297lb; equipped weight, 320lb; total with propeller 419lb; max rating, 440 s.h.p. (470 e.h.p.) with s.f.c. of 0.621 (consumption 294lb/hr) at 43,000 r.p.m. with j.p.t. of 941° F; continuous rating, 400 s.h.p. (425 e.h.p.) with consumption of 275.5lb/hr at 43,000 r.p.m. with j.p.t. of 878° F; pressure ratio at 43,000 r.p.m., 5.81.



Turboméca Bastan Single-shaft turboprop. Single-stage axial compressor followed by single-stage centrifugal compressor, annular combustion chamber and three-stage turbine. Overall diameter, 21.7in; overall length as depicted, 60.9in; dry weight of bare engine, 607lb; complete powerplant with propeller, oil tank, and cooler, 775lb; max rating 935 s.h.p. (1,000 e.h.p.) at 33,500 r.p.m. with j.p.t. of 510° C, s.f.c. of 0.605 and pressure ratio of 5.45; max cont, 740 s.h.p. (806 e.h.p.) at 33,500 r.p.m. with s.f.c. of 0.63.



Turboméca Turmo 3B Free-turbine turboshaft. Single-stage axial compressor followed by single-stage centrifugal compressor, annular combustion chamber, two-stage compressor turbine and single-stage rear output turbine. Overall diameter of bare engine, 31in; overall width of complete powerplant (as illustrated), 29.4in; length, 65.1in (approximately 74in as complete powerplant); dry weight of bare engine, 510lb; fully equipped, 560lb; complete powerplant, 600lb; take-off rating, 812 s.h.p. at 34,050 r.p.m. with s.f.c. of 0.67, with output r.p.m. of 5,325; normal rating, 640 s.h.p. at 34,050 r.p.m. with s.f.c. of 0.68; pressure ratio at 34,050 r.p.m., 5.65.

Turmo 3C: identical in design, but slightly heavier and having greater mass flow and top temperature; take-off rating 1,100 s.h.p. at 33,000 r.p.m. with s.f.c. of 0.68 and pressure ratio of 5.5; output will normally be limited to 900 s.h.p., which will be maintained up to 100° F or 10,400ft.

More than 70 types of rocket engine have been developed, chiefly running on Furaline and white fuming nitric acid. HTP and liquid oxygen have been investigated but abandoned for aircraft work. More than 45,000 liquid firings have been logged, and 12,000 tons of nitric acid consumed without incident. Although outside the scope of this review, SEPR are the principal continental source of large solid-propellant boost and sustainer units for missiles. Typical of their products in this field are the boost and sustainer rockets of the Matra R.422A; the former gives a thrust of 57,330lb for four seconds and weighs 1,817lb filled, while the latter weighs 569lb and gives a thrust of 3,530lb for 22sec.

SEPR 841 As the booster engine of the Mirage III, several hundred of these neat packages are in production, the engines themselves being subcontracted to Hispano-Suiza. The large oxidant tank fits within the rear fuselage and contains 69gal of nitric acid. This tank can be readily replaced by a conventional fuel cell. At its forward end is a flexible coupling through which a shaft from the Atar 9 turbojet is taken in (93.7 h.p. at 5,080 r.p.m.), to drive the turbopump. To the rear is secured the thrust chamber, canted slightly downwards. Two thrust levels, one approximately double the other, may be selected, but no intermediate thrust can be chosen. In the present installation the fuel is TxII (Furaline) 32gal of which are housed in a cell which replaces the Mirage gun pack. All structural portions of the powerplant are manufactured from light alloys, stainless steel being limited to rotating portions of the turbopump and to certain parts of the oxidant circuit. SEPR have cleared the unit for 50 air firings without overhaul.

SEPR 844 Under this designation has been evolved a refined version of the 841. Minor variations have permitted the use of kerosine (from the aircraft tanks) as fuel, and the thrust can be varied to any point between the two levels established by the 841. Most of the Mirage engines may actually be delivered as 844s.

SNECMA *Société Nationale d'Etude et de Construction de Moteurs d'Aviation, Paris 8.* A nationalized group formed from Gnome-Rhône, Renault Aviation and Lorraine, SNECMA have for 15 years been the largest aero-engine firm on the continent of Europe. By far the major part of their activities has been the development and production of the Atar family of turbojets, but they have also licence-built the Bristol Hercules piston engine, developed small pulsejets and turbojets larger and smaller than the Atar and manufactured two piston engines of native design. They have also been intimately concerned with the *Coléoptère* aircraft, and with a variety of jet-deflection systems.

For more than a year it has been obvious that SNECMA's current products are not likely to lead to substantial future business. Last year talks were held with Pratt & Whitney Aircraft with a view to the production by SNECMA of a derivative of the J75 turbojet for the projected Dassault Mirage 4. Eventually this deal fell through, but in January a nine-year agreement was announced, under the terms of which United Aircraft acquire 10.9 per cent of SNECMA's capital (a curious situation for a nationalized company) and are represented on the French company's Board, in return for a licence permitting SNECMA to manufacture all Pratt & Whitney piston and turbine engines and their spares.

This gives the American firm a solid foothold within the European Common Market. Although it seems unlikely that SNECMA will produce large quantities of any Pratt & Whitney engines, it means that these powerplants will have an almost unbeatable advantage within the Common Market; and the sales of spares to support the thousands of Pratt & Whitney engines already within that area will be considerable. It remains to be seen what effect the agreement will have on SNECMA's design ability.

Atar A history of this great family of single-shaft military turbojets was given in our issue of July 26, 1957. Originally stemming from a BMW engine of 1945, SNECMA finally placed the Atar 101D-1 in production in 1953 at 6,610lb dry for Mystère 2s of France, India and Israel. The addition of a zero-stage produced the 7,716lb 101E, for the Vautour (and used in many prototypes). With afterburner this engine became the 9,700lb 101G, for the Super Mystère.

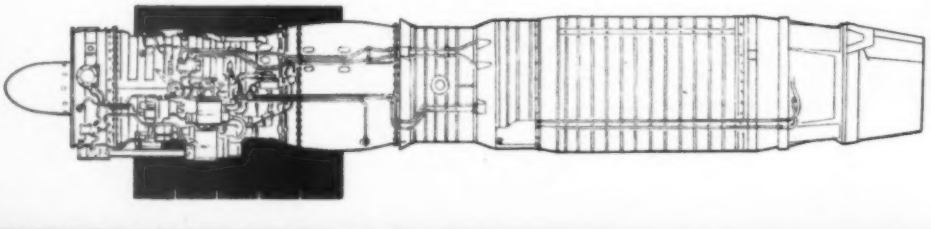
In 1956 SNECMA unveiled the completely redesigned Atar 8, with a two-stage turbine and a "00" stage, the new compressor operating at a pressure ratio of 5.5 instead of 4.8. The Atar 8 weighs 2,180lb and is rated at 9,700lb with s.f.c. of 0.98. It is in production for the Etendard 4M.

With afterburner the new engine becomes the Atar 9, for the Mirage 3 family. The present pre-series of these aircraft are fitted with the 9B, rated at 13,227lb with reheat. The installation includes bifurcated intakes with variable half-cone centrebodies, and an afterburner and propelling nozzle fully-variable according to the position of the power lever. Now in production is the 9C, for the first series of 100 Mirage 3Cs, with an all-steel compressor casing and an improved reheat system brought in at M1.4 and giving a maximum rating of 14,109lb. It will be succeeded by the Atar 9D, rated at 14,991lb. SNECMA stress the excellent performance of these engines; very encouraging high-subsonic consumptions are being recorded, and simple modifications investigated with an Atar E5 should reduce s.f.c. by a further five per cent.

Super Atar Brief details of this engine were given in our 1959 review. Intended for flight at M3, it is an all-steel unit with few compressor stages, high mass flow per unit frontal area and a large afterburner. Its development has virtually ceased.

TURBOMECA *Société Anonyme Turboméca, Bordes (Basses-Pyrénées).* After World War 2 this company was entrusted with the development of a gas turbine to drive an a.p.u. for a large cargo aircraft. The resulting Orédon, their first engine, went on test on August 25, 1948. By 1950 700 employees occupied a 207,000 sq ft plant, and the annual turnover was 582m francs. Today there are 1,500 employees on a floor area of 476,302 sq ft, and the annual turnover last year was 8,240m francs.

By January 1, 1960, the company had delivered 3,550 small gas turbines of many types. Deliveries are running at 100 or more engines monthly, and exports have been made to 21 countries (to a 1959 total of 2,600m Francs, roughly the same as the entire turnover for 1955). Britain, the USA, Spain and Yugoslavia have so far made 3,250 engines under



Snecma Atar 9 Military single-shaft turbojet with afterburner. Nine-stage compressor, annular combustion chamber with 20 burners in individual cups, two-stage turbine and variable-augmentation afterburner with three-position nozzle. Max diameter, 33.86in; overall length, 263.8in; dry weight, 2,755lb; max ratings, 13,228lb at 8,400 r.p.m. wet full reheat (s.f.c. 2.075), 11,905lb with partial reheat (s.f.c. 1.7) or 9,370lb dry (s.f.c. 1.1) with mass flow and pressure ratio of 149.9lb/sec and 5.5:1. Atar 9B, 9C: see text above.

licence, and the company's power units have been chosen for 45 types of aeroplane, helicopter and missile. More than 30 different types of engine have so far been built, of which the following are the most important.

Artouste Under this name has been evolved a family of turboshaft engines of a single-shaft layout. The most important is the Artouste 2B1, which for five years has been made for the Sud Alouette 2 helicopter. The take-off rating is 400 s.h.p. at 34,000 r.p.m. with a consumption of 377lb/hr, and the maximum cruising rating is 355 s.h.p. with a consumption of 346lb/hr. Installed dry weight is 360lb, the bare engine weighing 262lb. An FAA type certificate was awarded in January 1958, and a number have been sold by Continental for installation in Republic-built Alouettes. A variant has also been made by Blackburn Engines. At the beginning of this year Turboméca had delivered 610, and 260 remain to be built at 20 per month.

Superseding the 2B1 is the Artouste 3B, which has one of the company's new range of axial/centrifugal compressors operating at a pressure ratio of 5.2. This has enabled the take-off rating to be set at 542 s.h.p. for a fuel consumption of only 355lb/hr; and this is not the potential maximum, since it may be achieved at 40°C ambient and on a standard-day is maintained up to 14,300ft. The 3B weighs 410lb bare, or 578lb as installed in the Alouette 3. Six prototypes are running.

Astazou Revealed at the 1957 Paris Salon, this is the smallest of the new engines with an axial/centrifugal compressor. Owing to its very high r.p.m. it operates at a pressure ratio of 5.81, higher than that for any other Turboméca unit. It drives a two-blade Ratier-Figeac propeller at 2,420 r.p.m., and flight testing has taken place with a Max Holste 153 and Nord 1110 and two are to be installed in a Magister (previously a jet). The turboprop version has been selected to power the Potez 840 four-engined transport, and Astazous are being installed by SFERMA in a Beech Travel-Air and Dornier Do 27. The engine was certificated last month at the ratings given in the data panel.

Bastan Larger of the company's two new turboprops, the Bastan also has one of the axial/centrifugal compressors, but owing to the lower r.p.m. the pressure-ratio has been fixed at a point below that achieved by the Astazou. As a complete powerplant it is matched with a three-blade 9ft propeller and cowls perfectly. Initially designed to give around 650 h.p. it finally went on the bench at 750 h.p., was officially certificated in January 1959 at 805 h.p. and now has the ratings given in the data.

These ratings were certificated last December, when 4,700hr had been run, including a substantial amount of flying in a SFERMA-modified Beech PD.18. Bastans are being made for MS.1500 Eperviers, the Sud Voltigeur and Diplomate, the Dassault Communauté and Spirale and the MH.260 Super Broussard. The 40 prototype engines are currently being overhauled on a 500hr basis, and it is hoped that this time will double before the end of the year. A total of 50 pre-production Bastans are on order for equipping new airframes.

Marboré Largest of the first-generation engines with a simple centrifugal compressor, the Marboré has been made in greater quantity than any other Turboméca unit. On January 1 the plant at Bordes had delivered 2,150 and 650 remained on order, current production being at the rate of 75 engines monthly. An even greater number have been made in the USA by Continental (*q.v.*).

The most numerous French version is the Marboré 2, with a diameter of 25in, length of 62in, dry weight of 314/330lb, maximum thrust of 880lb at 22,600 r.p.m. with s.f.c. of 1.08, and normal rating of 710lb. Such engines are used in the Fouga 170 Magister, Fouga 175 Zephir, MS.760 Paris, and Nord CT.20 drone. A number have also been used in booster pods, particularly for the Nord 2502 Noratlas. Now in production is the Marboré 6, of 22in diameter, 56in length and 322/337lb weight. Although maximum r.p.m. are only 21,500 (reducing pressure ratio very slightly to 3.84), the greater mass flow has enabled both the take-off and normal ratings to be fixed at 1,058lb, with s.f.c. of 1.12. Maximum cruising rating is 926lb. The Marboré 6 has been flying in Magisters since last summer.

Turboméca's factory is situated at Bordes in the foothills of the Pyrenees. From the machine shop illustrated above have come the parts for some 4,000 small gas turbines since 1953

Palouste In this engine an oversize compressor is employed and the excess air delivered for a variety of purposes. Most Palouste are employed in ground applications (including the pneumatic starting of large aircraft) but many power the SO.1221 Djinn helicopters. At the beginning of the year Turboméca had delivered 340, and 40 remained on order for delivery at five per month. The most common version is the Palouste 4, delivering 9,000lb/hr at 41lb/sq in gauge for a consumption of 265lb/hr. Starting may be achieved by hand-cranking or a small petrol engine. Mention may be made of the Palouste 6, but no details are available.

Turmo Under this name has evolved a series of rear-drive free-turbine engines. The Turmo 1 and 2 are respectively rated at 270 and 400 s.h.p., but have been made only in small numbers in France (see Blackburn). French Turmo 2s are used in the Spanish Aerotecnica helicopters, the Bréguet 940 Intégral prototype and a Renault car.

Of greater importance is the Turmo 3B. This is the free-turbine member of the new axial/centrifugal family, and it gives correspondingly higher output with increased efficiency. Planned as a 700 h.p. engine, it was initially rated at 789 h.p. and now has the output quoted in the data. Last year (March 20) we illustrated the Turmo 3 as a bare unit, but this year's drawing depicts the complete powerplant of the Sud 3200 Frelon helicopter, in which three are geared to the single rotor. Turboméca are making 29 prototype Turmo 3s, and several are being tested by Sud and Aerotechnica.

GERMANY E

VVBF *Vereinegung Volkseigener Betriebe Flugzeugbau (Association of State-owned Aircraft Factories), Pirna/Elbe.* An outline of the work done by this national aircraft-production group was contained in our previous engine review. The engine factory at Chemnitz was only completed in 1954, and its chief tasks have been the production of the Soviet ASh-82T piston engine and the Type 014 turbojet of their own design. A description of this 6,945lb-thrust engine, together with a diagram and full specification, were given in our 1959 issue. It is in small series-production as the powerplant of the BB.152 airliner and may be used in the twin-engined BB.155.

GERMANY W

BMW *BMW Triebwerkbau GMBH, Munich, 68.* One of the most famous German aero-engine companies, BMW have re-entered this field on a large scale, with substantial government contracts for both the manufacture and overhaul of piston and turbine engines. The first assignment was the manufacture of several hundred GO-480 flat-six piston engines, under licence from the Lycoming Division of Avco, for Do 27s and Focke Wulf/Piaggio P.149Ds of the Luftwaffe. This was supplemented by the repair and overhaul of the Orenda 14s of the Luftwaffe's 225 Sabre 6s.

By far the largest BMW programme is the manufacture of the J79 turbojet, under licence from International General Electric, for the German F-104G. Some 550 are on order, and BMW have hopes of selling a similar number to Belgium, Holland, Italy and other NATO countries.

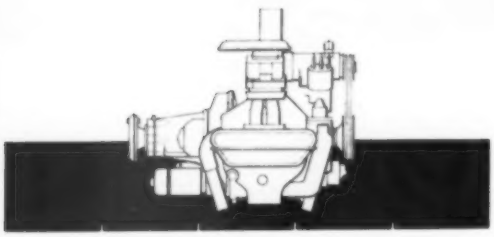
HEINKEL *Ernst Heinkel AG, Stuttgart-Zuffenhausen.* In our 1959 Aero Engines issue we described and illustrated the HeS 053 turbojet, rated at 14,300lb. This project has not been carried to fruition. Contracts remain, however, for the repair and overhaul of Turboméca Marboré II turbojets of the Luftwaffe.

KLOCKNER-HUMBOLDT-DEUTZ *Klöckner-Humboldt-Deutz AG, Cologne.* Under contract to the Federal government, who hold a licence from Bristol Siddeley Engines, KHD are tooling up for the quantity production of the Orpheus 803, to power German Fiat G.91s. Previously BMW had been named as likely to overhaul and repair this engine, but apparently all Orpheus work is to be placed with the Cologne company.

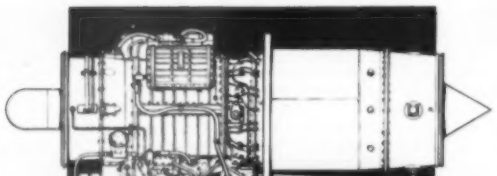
MAN *Maschinenfabrik Augsburg-Nürnberg AG, Dachauerstrasse 667, Munich 68.* Un-

official sources claim that this renowned company are to enter the field of aero engines with an advanced jet propulsion system for the VTOL combat aircraft under development by Südflug or Messerschmitt (and, according to the British Ministry of Defence, likely to be bought for the RAF). The first report said that the company were collaborating with Rolls-Royce and that they were developing the RB.153, a turbojet capable of being "feathered" to behave as a ramjet. A more likely statement, made by our French contemporary *Les Ailes*, is that the 153 is a 4,960lb turbojet, six of which will be used for both lift and propulsion (two fixed vertically and four swivelling).

PORSCHE *Dr-Ing h.c. F. Porsche K-G, Stuttgart-Zuffenhausen.* In Europe the various types of Porsche 678 flat-four are the most popular powerplants for the lightest types of aircraft. There are three main versions, but all have the same bore and stroke, of 3.25 and 2.91in respectively, a swept volume of 96.5 cu in and operate on 80-octane fuel. The unit illustrated is the most powerful of the series, replacing the 678/0 in production last year. The other engines are the 678/1, rated at 65 h.p., and the 678/3 direct-drive engine weighing 187lb and rated at 52 h.p. The Federal Air Ministry have provisionally laid down that all engines should be overhauled on a 600hr basis.



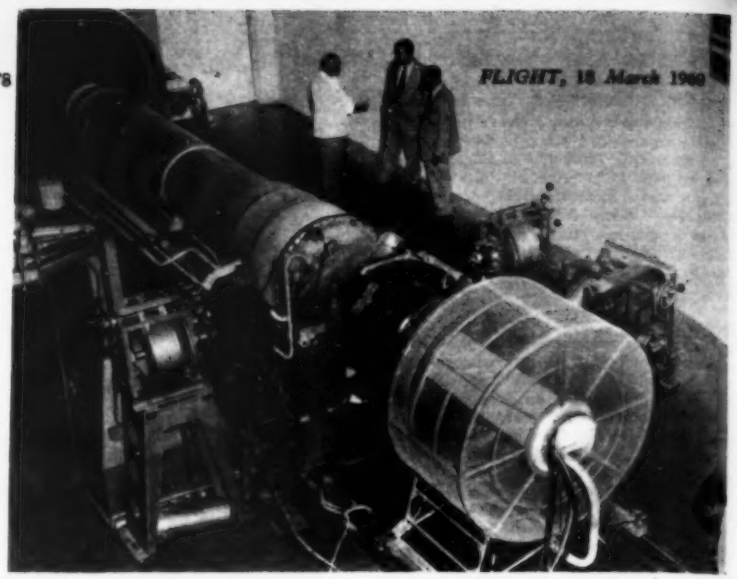
Porsche 678/4 Flat-four piston engine, geared but unsupercharged. Width, 32in; height, 25.4in; length, 28in; dry weight, 247lb; bore, 3.25in; stroke, 2.91in; swept volume, 96.5 cu in; take-off rating, 75 h.p. at 4,600 r.p.m. (2,325 propeller r.p.m.) with consumption of 5.25gal/hr; cruising rating, 60 h.p. at 4,270 (2,155) r.p.m. with consumption of 3.9gal/hr.



Nippon YJ3-3 Single-shaft turbojet. Eight stage compressor, annular combustion chamber and single-stage turbine. Overall diameter, 28.35in; length, 72.9in; dry weight, 816lb; max rating 2,646lb with s.f.c. of 1.08. Higher ratings are in prospect.

INDIA

HINDUSTAN *Hindustan Aircraft (Private) Ltd, Bangalore District, India.* In 1956 India's only major aircraft company established an engine division, and shortly thereafter signed a contract with Bristol Siddeley Engines for the licence-production of Orpheus 701s to power the Gnats manufactured by the company's aircraft plant. A new factory was put in hand for this purpose; the buildings are almost complete, most of the tooling has been installed and manufacture of Orpheus parts has begun. Hindustan overhaul and test large numbers of Rolls-Royce Avons for the Indian Air Force. The company are also developing the PE.90H flat-four piston engine, rated at 90 h.p. at 2,600 r.p.m. This engine owes much to American units, but is entirely indigenous with the exception of certain accessories. The first PE.90H ran last March, and certification is being sought.



As noted below, Hindustan Aircraft repair and overhaul the hundreds of Rolls-Royce Avons in service with the Indian Air Force. This is a Mk 203 engine from a Hunter 56

ITALY

AGUSTA *Meccanica Verghera Agusta, Gallarate (Prov Varese).* In our issues dated July 26, 1957 and March 20, 1959 we described and illustrated the chief engines produced by this versatile company. They are a 42 h.p. flat-twin and a series of flat-fours in the 80-86 h.p. range, the latter including a geared aeroplane engine and a vertical-crankshaft unit for helicopters.

FIAT *Fiat S.p.A., Divisione Aviazione, Corso G. Agnelli 200, Turin.* In 1947 this great company's Aviation Division entered the gas-turbine field by making Goblin and Ghost turbojets under licence from DH Engines and in overhauling these powerplants for the Italian Air Force and French Navy. Large contracts were subsequently placed by several air forces for the overhaul of Allison J35s, General Electric J47s, Wright J65s and several piston engines. Under licence from Bristol Siddeley the main plant at Lingotto has been tooled for the manufacture of the Orpheus 803 to power the Fiat G.91 attack aircraft for several NATO nations. Deliveries of Fiat-built Orpheus are about to begin. The company has also designed several small gas turbines. One of these, the 4032 turbojet, is in the same general category as the Orpheus and no information on its development is available. It was described in our last Aero Engines issue (March 20, 1959).

4002 A description of this tiny turbojet appeared on page 127 of our issue of July 26, 1957. It has been designed for trouble-free operation in a range of light civil and military aircraft. It has not yet flown.

4700 A description of this unusual powerplant appeared in our last Aero Engines of the World issue, dated March 20, 1959. Incorporating several components previously developed for the Fiat 4002 turbojet, it is intended to supply air for cold tip-drive of the rotor of the Fiat 7002 helicopter. The prototype engines have completed some hundreds of hours of running and should take the first 7002 into the air during the coming summer. In principle the unit is reminiscent of the Napier Oryx, but in design points are less ambitious. Although successful, the British engine was cancelled owing to shortcomings in the basic concept.

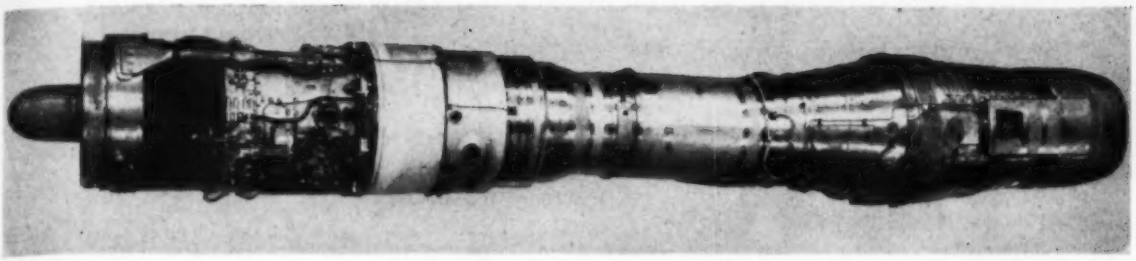
JAPAN

ISHIKAWAJIMA *Ishikawajima Heavy Industries Co Ltd, 1010, Tanashi-Machi, Kitatama-Gun, Tokyo, Japan.* Since 1955 this large industrial firm has been a licensee of International General Electric. In June 1956 they were authorized to manufacture spares for J47s to support USAF and Mitsubishi-built Sabres, and large numbers of parts have since been delivered from the Tanashi works. Ishikawajima are also likely to be chosen to manufacture the complete J79 to power the Lockheed F-104J series, 200 of which are to be assembled by Mitsubishi. The company are also manufacturing J3 engines developed by the Nippon Jet-Engine Co (*q.v.*).

NIPPON *Nippon Jet-Engine Co, Tokyo.* An *ad hoc* consortium formed by several large industrialists, this group has designed and produced two small turbojets, both owing something to early American engines. First was the J0-1, described in our Aero Engines issue of May 11, 1956. Their current powerplant is the J3.

J3 In design this engine differs from the J0 largely in having an annular combustion chamber, which has permitted the mass flow to be raised. The thrust/weight ratio is still very poor, but the J3 is essentially a design upon which teeth can be cut rather than an optimum product. It was originally hoped that the J3-3 version might become the powerplant of the Fuji jet trainer. The superiority of the Bristol Siddeley Orpheus 805 has been rewarded by the first production contract, but a T1F-1 (T1A prototype) is scheduled to fly on the power of one of the pre-production YJ3-3s this month.

Features of the design include forged steel compressor blading, an automatic mechanical-type control system, dual-manifold fuel supply with flow-divider downstream of an NJE fuel pump and flow control, dry-sump forced oil



Svenska Flygmotor are producing hundreds of advanced Rolls-Royce Avons with a fully-variable afterburner of their own design. The powerplant above is the RM6B, for a J-35A Draken. Later versions of the Draken have a rather larger and more powerful powerplant based on the Rolls-Royce RB.146

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system and Shinko Denki starter/generator. By last month the company had completed eight J3s and Ishikawajima had made three. Three pre-production YJ3-3s have been delivered to the Japanese Defence Agency, one of which started altitude testing last December mounted in a pod beneath a C-46D.

POLAND

THE reconstituted nationalized aircraft industry has settled down, and is producing quantities of light piston engines, together with the Russian VK-1A (Nene-derivative) turbojet, and certain Russian piston engines. Descriptions of all the powerplants in current production were contained in our review of March 20, 1959. No further details are available on the only indigenous gas turbines, respectively a turboshaft/turboprop engine in the 1,000 h.p. class and a turbojet of some 1,000lb thrust.

SPAIN

ENMASA *ENMA, SA, Antonio Maura 4, 2°, Madrid.* An account of the work of this national organization was given in our last Aero Engines issue (March 20, 1959). ENMASA state that there has been no substantial change since that issue was published. Series-production of the Turboméca Marboré 2 has got into its stride, to meet the requirements of the locally built Hispano Saeta and Saeta Voyager. ENMASA also overhaul French-built Turboméca Artoustes imported for Aerotecnica helicopters.

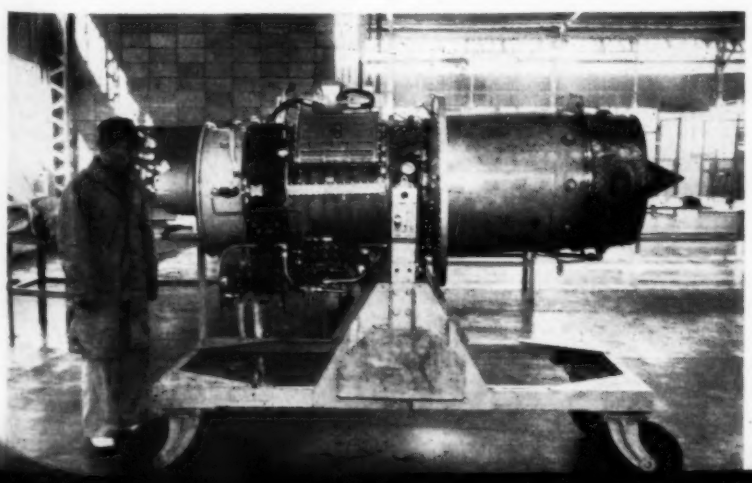
SWEDEN

FLYGMOTOR *Svenska Flygmotor AB, Trollhätten.* Since 1950 this company has concentrated its activities upon the de Havilland Ghost and Rolls-Royce Avon. These turbojets have both been re-engineered in detail and manufactured in great quantity for the Royal Swedish Air Board. Both have been produced with Flygmotor's own afterburners and control systems, and have given outstanding service. The Ghost, designated RM2B for the various versions of Saab-29, weighs 2,510lb and has maximum ratings of 4,750lb dry and 6,200lb with reheat. It was described in our July 26, 1957, issue. The Avon 100-series has been manufactured as the RM5A for the A-32A Lansen. Production is continuing upon the RM6B (Avon 200) with afterburner for J-32B Lansens and J-35A Drakens, at an afterburning rating of approximately 15,000lb. These engines were described in our issue of March 20, 1959. They will be superseded in production by a Flygmotor version of the Rolls-Royce RB.146, for the J-35B Draken.

USA

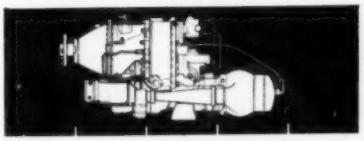
AIRCOOLED MOTORS *Aircooled Motors Inc, Liverpool Road, Syracuse 8, NY.* Makers of the well-known series of Franklin engines, this company continues to concentrate on helicopter powerplants. The majority are flat-fours and flat-sixes of 335 cu in displacement, with a vertical crankshaft. The latest is the turbosupercharged 6VS-335, rated at 225 h.p.

Japan designed and built a small turbojet during 1944-5, but this programme was halted by military occupation. Now Japan has taken up the threads again, and the latest of a family of simple turbojets is the YJ3-3. One of these is about to fly as the powerplant of a TIF-1 trainer



ALLISON *Allison Division of General Motors Corp, Indianapolis 6, Indiana.* Like Curtiss-Wright, Allison have been forced to surrender major parts of the aero-engine spectrum and diversify. Many thousands of their J33, J35 and J71 turbojets—described in our Aero Engines issues up to that of July 26 1957—remain in world-wide service. The company appear to have abandoned the development of the J89 and other large supersonic turbojets, and with the termination of the USAF contract for the development of the T61 the company's aero-engine work has contracted to two shaft-turbine programmes: the tiny Model 250, which may have a tremendous future; and the T56/Model 501, the future for which is probably more limited.

Allison have announced no plans to produce other aero engines, but there have been well-founded reports to the effect that they are anxious to conclude a licence-agreement with Rolls-Royce which would enable them to manufacture and develop units from the British company's range of optimized commercial



Allison 250-B2 (T63-A-1) Free-turbine turboprop. Seven-stage axial compressor followed by single-stage centrifugal compressor, twin delivery manifolds to single combustion chamber, single-stage compressor turbine and two-stage independent power turbine. Overall width, 15.8in; height, 19.3in; length, 38.9in; dry weight, 106lb; guaranteed performance, max rating (up to 100° F), 250 s.h.p. at 2,000 propeller r.p.m. with s.f.c. of 0.70 at 59° F rising to 0.73 at 100° F; 75 per cent power, 159 s.h.p. with s.f.c. of 0.81; military rating at 6,000ft, static, 59° F, 206 s.h.p. with s.f.c. of 0.72.

engines. The engine specifically named in this context is the RB.163, which according to one account differs from its progenitor in having a zero-stage.

Model 250 During the winter of 1957-8 Allison drew a baby turboshaft engine, to have exceptional reliability, performance, ease of maintenance, durability, low weight and cost. They believed that they stood a chance of beating the "price barrier" which has for so long kept the gas turbine out of the small-power field. After extensively surveying the market—covering a great range of applications, only some of which were concerned with flying vehicles—the Allison Model 250 was formally presented to the American military services on March 10, 1958. The company received a development contract in June of that year, established production configurations for turboshaft and turboprop versions at a mock-up review in November and had the first engine running on the bench last April 1.

The configuration, described in the data panel, represents the optimum compromise between many conflicting factors. The choice of a free-turbine layout is logical, but the engine breaks new ground among small turbines in having a remarkable compressor with a pressure ratio of about 6.2, which did not require a two-stage turbine to drive it yet permitted the s.f.c. to be brought down to

about 0.7 at military power even with a turbine-inlet temperature well below 1,750°F. Holding down top temperature has enabled Allison to produce the 250 as a full-power engine (instead of 192 h.p.) on a 100°F day. The control system was evolved around the simplest mechanical/hydraulic concept capable of performing the required functions automatically, and has worked well during intensive bench running.

Manufacturing costs are critical in establishing the market potential of an engine of this character. Typifying their bold approach, Allison have evolved a method by which complete compressor rotor stages are precision cast in an aluminium/cobalt alloy or reinforced plastic, the resulting assembly of disc and blades requiring virtually no machining and costing less than a third of an equivalent part produced by any other method. From the precision-cast centrifugal stage the air is delivered through a vaneless diffuser to a collector scroll, thence passing to the rear through lateral pipes to the single combustion chamber. The hot gases move forward through the gas-generator and power turbines and are discharged through an exhaust hood projecting straight downwards.

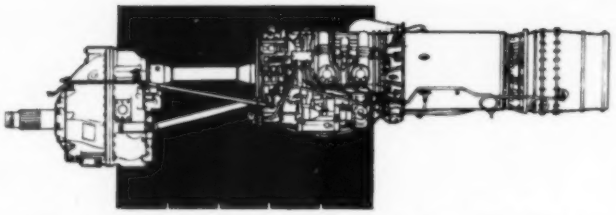
The backbone of the engine is the gearcase; the compressor is bolted on the front, the combustion chamber is bolted to the rear and inside is the train of spur gears which take the power to an upper output shaft turning at 6,000 r.p.m. From the latter, drives can be taken to front or rear, and in the turboprop version a planetary reduction gear provides a final output at 2,000 r.p.m. An additional train from the gas-generator assembly provides drives to the accessory pads on the front and rear faces of the gearcase.

Military sponsorship has been obtained in the form of a joint development contract from the Army and Air Force as the T63. A considerable number of pre-production engines are undergoing intensive development for all types of light aircraft, helicopters, VTOL platforms and similar devices. Certification may be obtained this year, and it is unofficially suggested that the selling price for a turboshaft unit may not exceed £2,000.

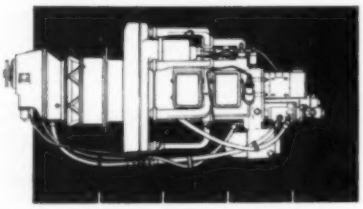
Model 252 A project consisting of the fore and aft ends of a pair of Model 250 engines bolted to a common gearcase and driving a single output shaft. The 252 has been designed in detail in both turboshaft and turboprop forms but has not yet been built.

Model 501 As the commercial derivative of the T56, the 501 is a highly developed engine, in airline service powering Lockheed Electras since January 1959. Unlike the military engine, the propeller axis lies below that of the power section. Several hundred 501-D13s are now operating at an overhaul life of 1,000hr. Admittedly the Allison is a simple engine, but the company deserve considerable credit for having made it a genuine thousand-hour powerplant, with no teardown or parts-replacement at any intermediate point. No other US gas turbine has achieved this goal.

Among its features are: β-control of the 14ft 6in propeller; a system for reducing r.p.m. on the ground, and so make less offensive noise, while maintaining constant-speed operation at all other times; and provision for bleed-air anti-icing and an air-turbine starter. At present the D13 is being marketed as an integrated package, which has been bought by one operator as part of an Allison programme to revitalize the Convair-Liner. The company have also evolved the 501-D15, corresponding roughly to the T56-A-7, in which minor improvements (including shrouded first and second turbine stages) have raised the mass flow and pressure ratio to the same levels as those of its military counterpart (*q.v.*).



Allison 501-D13 Commercial single-shaft turboprop. Fourteen-stage compressor, can-annular combustion chamber with six flame tubes and four-stage turbine. Overall width, 27in; max overall height, 36in; length as depicted, 145.2in; dry weight, bare, 1,750lb; max rating, 3,460 s.h.p. (3,740 e.h.p.) at 13,820 r.p.m. with mass flow of 39lb/sec, pressure ratio of 9:1 and s.f.c. of 0.54; max cont rating at 25,000ft at 360 kt, 1,850 s.h.p. (1,905 e.h.p.) at 13,820 r.p.m. with s.f.c. of 0.46.



Boeing Model 520-8 Free-turbine turboprop. Rear intake to double-entry centrifugal compressor, two reverse-flow combustion chambers, inward-radial compressor turbine, independent axial power turbine, multi-stage spur reduction gears and annular front exhaust. Overall diameter, 25in; length, 59in (68.67in over spinner); dry weight, 275lb; max rating, 550 s.h.p. at 2,400 output r.p.m. with s.f.c. of 0.65; guaranteed minimum rating, 520 s.h.p. (540 e.h.p. assuming 59lb jet thrust) at 2,300 r.p.m. with max s.f.c. of 0.66lb/hr/s.h.p.; estimated rating with 25hr life at 40,000ft and 400kt, 270 s.h.p. with s.f.c. of 0.5.

Model 550 Since 1955 Allison have had under development a turboprop which represents a natural outgrowth of the Model 501, with a two-spool compressor. A development contract was placed by the US Air Force, the engine receiving the military designation of T61. Matched with a special Aeroproducts propeller, it was intended eventually to power the Lockheed Super Hercules. Despite substantial commercial interest, headed by PanAm and Slick, and pressure by Congress to buy the aircraft for MATS, no order for the Super Hercules materialized and no other application for the engine has been announced. The development contract finally expired last November 30 and development has virtually ceased. Total USAF funding had amounted to $35m. When the contract came to an end four YT61-A-1s were running on the bench, a YC-130B was being modified to take a T61 in the No. 3 position and the 50hr test was scheduled for this month.

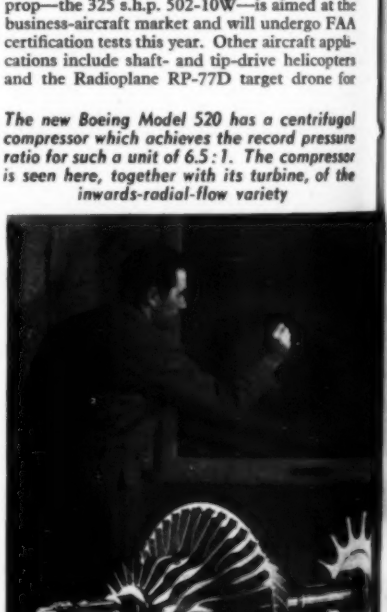
The original design power of 5,500 e.h.p. was substantially exceeded on the bench, but the s.f.c. was never really competitive. Design features include: a low-pressure compressor with six stages within a tapering casing; a high-pressure compressor with eight stages of blading and an untapered casing; a can-annular combustion chamber with seven flame tubes; a single-stage high-pressure turbine; and a four-stage low-pressure turbine driving through a central shaft to the low-pressure compressor and thence to the propeller reduction gear carried remotely on a lower level.

Dry engine weight is quoted as 2,240lb. Bench running enabled the following ratings to be established (sea-level standard day): take-off, 6,500 e.h.p. (6,102 s.h.p. + 996lb thrust) with minimum s.f.c. of 0.5 and turbine inlet temperature of 1,855°F; military rating, 6,235 (5,873 + 905)/0.505/1,855; normal, 5,635 (5,294 + 853)/0.515/1,775; 90 per cent cruise, 5,070 (4,770 + 750)/0.535/1,735; 75 per cent cruise, 4,225 (3,966 + 647)/0.56/1,650. Guaranteed s.f.c. at normal power at 320kt at 35,000ft was to be 0.51.

T56 Well over 1,000 of these single-shaft turboprops are in service with the US Air Force as the powerplant of the Lockheed C-130 Hercules. Most of the engines in use are of the T56-A-1A and A-9 types, both rated at 3,460 s.h.p. (3,750 e.h.p.) and installed in C-130As driving a three-blade 15ft Curtiss propeller. These engines have now been superseded by the T56-A-7, rated at 3,755 s.h.p. (4,050 e.h.p.), which is matched with a four-blade Aeroproducts propeller in the C-130B. These engines were described in our earlier Aero Engines issues, such as that for July 26, 1957. About to enter production for the Lockheed P3V (ASW Electra) is the T56-A-10W, which incorporates a water-injection system and other detailed improvements. Maximum rating is 4,585 e.h.p.

BOEING *Industrial Products Division, Boeing Airplane Co, Seattle 24, Washington.* For 17 years this company has been active in the field of small turbines, and the 502 series has established a high reputation for reliability and trouble-free service in marine, industrial, vehicular and aircraft applications. Bench testing began in 1947, the output being 100 h.p. and the s.f.c. 1.8; the current production version is the 502-10CA, rated at 240 s.h.p. with s.f.c. of unity. Almost 1,000 similar engines have been delivered, and six variants are currently in production or under test. One turboprop—the 325 s.h.p. 502-10W—is aimed at the business-aircraft market and will undergo FAA certification tests this year. Other aircraft applications include shaft- and tip-drive helicopters and the Radioplane RP-77D target drone for

The new Boeing Model 520 has a centrifugal compressor which achieves the record pressure ratio for such a unit of 6.5:1. The compressor is seen here, together with its turbine, of the inwards-radial-flow variety



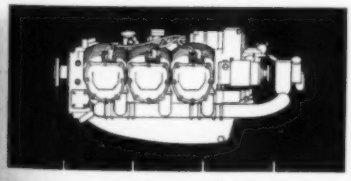
the Army. The latter is powered by the 502-10S turboprop, rated at 360 h.p. at 3,400 r.p.m. with s.f.c. of 0.9 and a weight of 325lb. These drones can exceed 400 m.p.h. and have reached 46,500ft. More than 180 Boeing 502-11B air compressors, developing 205 air h.p., have been ordered by ten airlines as ground support units.

Model 520 In every respect this engine marks a significant advance over the 502. In particular the new double-entry compressor runs with a tip speed of 1,750ft/sec to achieve a pressure ratio of 6.5, greater than that of any other single-stage centrifugal compressor known. There are two cup-type reverse-flow combustion chambers, both located at the top of the engine, and the free power-turbine can provide constant power over one-third of the range of output r.p.m. for any selected compressor speed.

In our last Aero Engines issue (March 20, 1959) we described the Model 520-2 (US Navy YT60-BO-2), which started bench running in March 1958. The first-generation versions are the -2, of 325lb weight and 400 s.h.p. or 412 e.h.p. at 6,200 output r.p.m. with s.f.c. of 0.72, and the corresponding -4 turboprop, which weighs 15lb more and has a take-off rating of 475 minimum s.h.p. or 495 e.h.p. at 2,390 propeller r.p.m. with s.f.c. of 0.71 (0.68 on an e.h.p. basis). When fitted to a recoverable target aircraft, assuming full ram recovery and a 25hr life, this engine could be rated at 500 s.h.p., and at 40,000ft at 400kt could deliver 235 s.h.p. with s.f.c. of 0.56. These engines are scheduled to be on the commercial market next year.

Succeeding them are the advanced 520-6 turboshaft engine and the -8 turboprop. Data for the latter are given with the drawing; the former weighs only 260lb and will have a minimum military rating of 525 s.h.p. or 545 e.h.p. at 6,250 output r.p.m. with s.f.c. of 0.65 (0.63 on an e.h.p. basis). FAA certification testing of these advanced units should begin in approximately two years, and both models are to be on the market before 1964.

CONTINENTAL *Aircraft Engine Division, Continental Motors Corporation, Muskegon, Mich.* For many years Continental have been one of the world's foremost producers of lightplane engines. Piston engines are the responsibility of the aircraft engine division. A subsidiary company, Continental Aviation and Engineering Corp, was formed in



Continental IO-470D Flat-six piston engine, unsupercharged and ungeared but with direct injection. Width, 33.56in; height, 19.75in; length, 43.31in; bore, 5in; stroke, 4in; swept volume, 471cu in; dry weight, 426lb; max rating, 260 h.p. at 2,625 r.p.m.

1940 to undertake research and development. In 1951 this subsidiary purchased a manufacturing licence for Turboméca engines and their work in this regard is described separately.

Aircraft Engine Division The flat-fours and flat-sixes from Muskegon are possibly the most successful in the world at the present time. Newest of the wide range are the direct injection IO-470 series. The injection system is simplified, consisting only of a pump, control unit, manifold valve, discharge nozzles and fuel-pressure indicator (which correlates pressure with fuel consumption). Typical of these engines is the IO-470D, operating on 100/115 grade fuel, with a compression ratio of 8.6, weight of 426lb and with take-off and rated output of 260 h.p. at 2,625 r.p.m. The company have paid little attention to helicopter engines, only the 270 h.p. FSO-520A coming into this category.

Gas Turbine Division This division of the CAEC subsidiary is located in Detroit. By far the most important of the many Turboméca-derived engines built there is the Marboré, of which 2,700 have been produced in several models as the J69. Nearly all have been manufactured to power Cessna T-37 trainers of the USAF, and the most common variants are the J69-T-9 (920lb rating) and T-25 (1,025lb). Considerable numbers of similar engines have been used in various types of Ryan Firebee drones and in the latest Q-2C versions the engine is the uprated T-29 of 1,700lb thrust. This drone is now in full production. The T-29 incorporates an axial stage similar to that of the latest Turboméca engines, and a variant for manned aircraft is the Model 356-9, derated to 1,400lb for the Cessna 407 executive machine. Other Turboméca-derived engines include air compressors with both ground and airborne applications and turboshaft engines derived from the Artouste.

Occupying facilities at Edwards AFB, California, the principal flight test centre of the General Electric Company operates aircraft which frequently exceed 90,000ft altitude and twice the speed of sound. Visible in the photograph are a McDonnell F-101A, Douglas XF4D-1, Grumman F11F-1F, Lockheed F-104A, North American F-86D, Boeing B-47E, and Chance Vought Regulus II

GENERAL ELECTRIC *The General Electric Company, Aircraft Gas Turbine Division, Cincinnati 15, Ohio.* It was natural that this huge firm should have been picked to produce the first American gas turbine. Based on designs of Sir Frank Whittle, this unit ran in 1942 and since that year GE have made more gas turbines than any other firm (32,000). Some 36,500 J47 turbojets have been made, 28,000 by GE, and during the early 1950s the aircraft gas turbine division [illegible]lved the J53 supersonic turbojet, and the [illegible]lb J73.

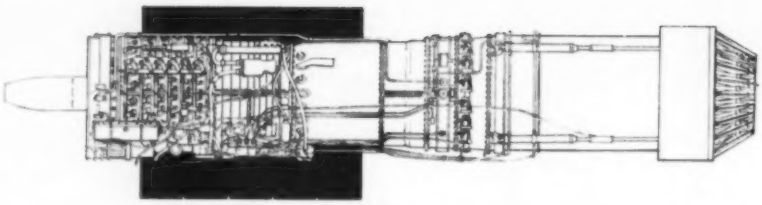
While these en[illegible]were settling down, the flight propulsion [illegible]on planned a new turbojet, aiming at M[illegible]ruise and M2 combat with low weight and consumption. It was concluded that the optimum configuration was a high-pressure single-shaft engine with variable stators, and the company's current turbojet and shaft engines follow this layout. The classic example is the J79, now to be built in five nations for the Lockheed F-104. From it was evolved the CJ-805 commercial engine, which in turn has led to a range of aft-fan derivatives. Both the T58 and T64 turboshaft units are likely to be very successful, the little J85 turbojet is in moderate production and the great J93 may yet be built in some numbers.

The T58, J85, T64 and CF-700 small fan are being developed at Lynn, Massachusetts, by the Small Aircraft Engine Department. GE also remain prime contractors to the US Air Force for the only nuclear aircraft powerplant currently in advanced development. This engine is the X-211. Altogether, however, business in this field is contracting. Indicative of this is the fact that 1,200 have been laid off at the main plant at Evendale, Cincinnati, since January 1.

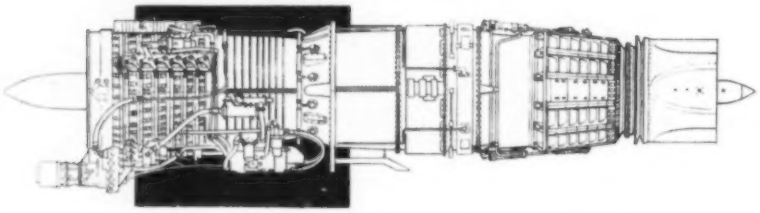
CF-700 This projected small turbofan is based on the J85 turbojet. General Electric's technique of adding a fan at the back of an existing turbojet has much to commend it; it does not affect the basic turbojet at all, the fan can be regarded at all times as an independent unit and the overall powerplant can be made operationally flexible. On the other hand, it has the effect of making the engine altogether bigger and heavier and the additional thrust is partly counterbalanced by the higher installed drag. The fat aft-fan is particularly applicable to a relatively slow aircraft, and the CF-700 has been designed for M0.5 to 0.9.

This low design flight Mach number has led to the very high by-pass ratio of 2:1. The free-floating fan is virtually a scaled CJ-805-23 unit, and is likewise carried in a front ball bearing and aft roller bearing. A cross section of the engine appeared in our issue of October 30 last. Design specification is: diameter, 33in; length, 70in; dry weight, 585lb (665lb with reverser); maximum rating 4,000lb (average) with s.f.c. of 0.69; max cruise 3,254lb with s.f.c. of 0.68; max cont at 25,000ft at 482kt, 1,593lb with s.f.c. of 1.01; max cruise at 36,089ft at 459kt, 1,020lb with s.f.c. of 0.97.

CJ-805 Airline derivative of the military J79, this engine differs only in detail. Conscious of their lack of commercial experience, GE have conducted exceptionally extensive tests of the CJ-805-3 for the Convair 880, and have accumulated high time on individual engines. Eleven -3s have been used at Evendale. The primary test consists of a series of 1,000hr schedules representing simulated airline operations. At the end of last year the programme had reached the following points: total running time, 9,437hr; max time on one engine, 3,586hr; total time in thrust reverse, 204hr

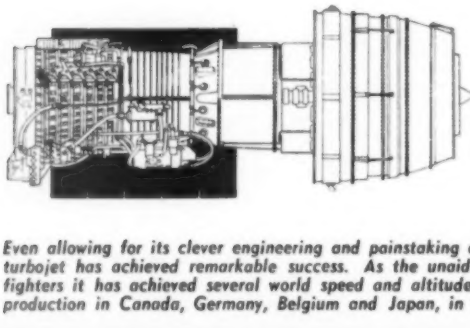


General Electric J79-GE-3A Military single-shaft turbojet. Seventeen-stage compressor with variable inlet guide vanes and first six stators, can-annular combustion chamber with ten flame tubes, three-stage turbine and afterburner with fully variable con-di nozzle. Overall diameter, 32.5in (36in at nozzle shroud); length as depicted 207in; dry weight, approximately 3,255lb; max rating, 11,000lb dry (s.f.c., 0.81) or 15,500lb with full reheat, with mass flow of 162lb/sec and pressure ratio of 12.5:1.



General Electric CJ-805-3 Commercial single-shaft turbojet. Seventeen-stage compressor with variable inlet guide vanes and first six stators, can-annular combustion chamber with ten flame tubes, three-stage turbine, reverser and suppressor. Diameter, 31.6in; length, 188.94in (bare engine 109.56); weight, 3,190lb (bare engine 2,800lb); take-off power, 11,200lb at 7,684 r.p.m. with s.f.c. of 0.806; corresponding mass flow, pressure ratio and temperature, 167.9lb/sec, 13:1 and 1,155° F; max cont, 9,500lb with s.f.c. of 0.738; max cruise, 8,850lb with s.f.c. of 0.728.

CJ-805-33 Improved materials to increase thrust; weight, 3,200lb (bare engine 2,815); take-off power 11,650lb at 1,185° F; s.f.c. at max cont, 0.728; max cruise, 9,190lb; all other details as -3.



General Electric CJ-805-23 Commercial turbofan. The gas-producer is that of the CJ-805 turbojet. Diameter of compressor front frame, 31.6in; diameter of fan front frame, 53in; length, 144in; dry weight as depicted, 3,825lb; max rating, 16,100lb with s.f.c. of 0.541; corresponding turbojet conditions, 7,684 r.p.m., 167.1lb/sec at 13:1 and 1,010° F; corresponding fan conditions, 5,727 r.p.m., 250lb/sec at 1.6:1; max cont power, 13,700lb with s.f.c. of 0.505; max cruise, 13,300lb with s.f.c. of 0.504.

Even allowing for its clever engineering and painstaking development, General Electric's J79 turbojet has achieved remarkable success. As the unaided powerplant of USAF and Navy fighters it has achieved several world speed and altitude records, and it is now going into production in Canada, Germany, Belgium and Japan, in the afterburning version seen here

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(13,000 cycles); max time on one reverser 37hr (4,424 cycles); total time on suppressors, 9,000hr; max time on one suppressor, 1,566hr. Flight testing late last year had produced 594hr on 16 engines. One had accumulated 1,059hr in the Navy-leased XF4D. Two -3s have each run 1,222hr in an RB-66A; one had previously run 2,000hr on the bench, and the other has actually flown 1,111hr. In the first eight months of flying the first CV-880 flew 165hr; aircraft No 3 flew 136hr in five months on production powerplants with reversers, and the fourth machine flew 59hr in two months. At the time this report was prepared there had been two in-flight malfunctions in these aircraft.

The -3B has slightly revised accessories and improved turbine materials to permit a rise of 30°F in turbine temperature. Some 15,000hr of -3 running preceded the -3B, and the first -3Bs are due for delivery this July for use in the CV-880M. The basic -3 is now about to enter passenger service and it is expected that an overhaul time of 1,000hr will be achieved this year.

CJ-805-23 This remarkable powerplant consists of a CJ-805 to which has been added a mechanically independent aft-fan assembly. The latter consists of a row of 54 double-deck "bluckets," comprising inboard turbine blades operating at 950°F and outboard fan blades operating at 200°F. Fan diameter is 48.8in and at 5,636 r.p.m. the tip speed is 1,190ft/sec. Extensive rig and bench testing has brought the fan to an advanced state of development. The first 50hr test was complete on a CJ-805-21 in December 1957. Several hundred hours on the -21 enabled GE to develop the -23, which has 14 per cent greater maximum thrust and in which aerodynamic improvements have made possible a significant reduction in cruising consumption, for a total weight penalty of only 25lb.

Five -23s are now in various phases of factory testing at Evendale and environmental testing and reverser tests are in hand at the outdoor facility at Peebles. A complete CV-600 pod is running in a cell at Evendale and the first pair of -23s to be flight tested are now well into an intensive flight programme in the RB-66A. At the beginning of the year 2,079hr had been logged, the highest time on an individual -23 being 627hr.

Around this engine Convair designed the CV-600 Coronado transport. The Convair-designed installation has a single pitot intake and an internal flow divider. The central flow passes direct to the compressor and a pair of lateral kidney-section ducts lead to the fan. At the rear is a large reverser handling both hot and cold flows, but no silencer is necessary.

General Electric are anxious for the -23 to be accepted as the alternative powerplant for the Sud or Douglas-built Caravelles. They have purchased a Caravelle and intend to undertake certification flying of the conversion in the late summer. A variety of growth versions of the aft-fan engines are projected, but GE are not pushing these until they see how their straight CJ-805 turbojet behaves in service. Military variants have received USAF sponsorship as the TF35, but no application has yet been announced.

J79 A design analysis of this outstanding single-shaft military turbojet was published in our issue dated July 26, 1957. In its design GE elected to use variable stators in order to achieve flexible, stall-free operation in a high-pressure engine with only three main bearings.

The opportunities of reducing weight were exploited by employing new methods for welding relatively thin steel sheet and by carrying all primary loads through the outer shell. The variable stators are actuated by a fuel ram automatically scheduled as a function of r.p.m. and compressor inlet temperature.

Production began in 1957, and at least 1,000 have now been delivered for a variety of USAF and Navy aircraft, nearly all of which are designed for M2. In the F-104 the J79 has held a world speed record (1,404 m.p.h.); it currently holds the world altitude record (103,395ft) in this type of aircraft and has held three previous altitude records in the F-104, F4H and F11F-1F. Major variants include the J79-GE-2 (afterburning engine for A3J Vigilante); -3A (illustrated); -5 and -5A (15,500lb engine for production B-58As); and -7 (16,000lb engine for advanced F-104s). The J79-GE-9 was developed for the advanced B-58 Hustler; it cost $19.5m in fiscal 1959 and, although cancelled together with its application, is still being flight tested.

J85 A description of this small single-shaft turbojet was published in our issue of December 11 last. Originally conceived as a simple unit of high thrust/weight ratio for pilotless drones, it has now evolved as an afterburning engine for the Northrop T-38 Talon and N-156 Freedom Fighter. Principal production versions will be the J85-GE-3 (15hr unit for the GAM-72 Green Quail diversionary missile); the -5 (first of a new series with a zero stage, rated at 2,500lb dry and 3,850 with maximum reheat for the Northrop aircraft and the Radioplane Q-4B supersonic drone); and the -7 (non-afterburning zero-stage engine for later Quails, weighing 325lb and rated at 2,450lb). The J85 is the basis of the CF-700 fan engine.

J93 Until last year this beautifully conceived single-shaft turbojet was the most important engine in America, two major versions being planned for the F-108 Rapier intercepter and B-70A Valkyrie intercontinental bomber. However, the Rapier contract was cancelled last September, and at the end of the year the Valkyrie was reorientated at a "prototype aircraft programme." The J93 is a lightweight, single-shaft variable-stator turbojet, with a small number of compressor stages but an exceedingly high specific airflow and a large afterburner and variable nozzle. In any application it would be installed behind a sophisticated fully variable intake system. The engine of the Rapier would have been the J93-GE-3, weighing some 4,000lb with afterburner and burning JP-6 fuel. Maximum reheat rating would have been approximately 30,000lb. For the B-70 the powerplant would have been the -5, with an even more advanced reheat system burning a boron-based fuel. As things stand at present two B-70s are to be constructed as research aircraft, using engines similar to the -3 or -3A. At least one unit of this type is now on the bench, and a $10.8m contract to maintain progress was placed on January 29.

T58 Since 1954 this small turboshaft engine has been a major project of the Small Aircraft Engine Department, principally under contract to the US Navy. Unlike most engines in its class it has a multi-stage axial compressor with variable stators, and its relatively ambitious design points confer an outstanding performance. Bench testing began in April 1955. Some 19,000hr of ground testing and approximately 2,000hr of flight time in several types of helicopter have now been logged, and the total is expected to reach 45,000hr by the end of the year.

Current production engines are chiefly the CT58-100 (T58-GE-6) variety, which has been awarded an FAA type certificate and is being produced for the S-61, S-62, Vertol 107 and Kaman HU2K. Considerable time has now been logged on the -8, with a half-hour rating of 1,250 s.h.p. The British version is the de Havilland Gnome (*q.v.*).

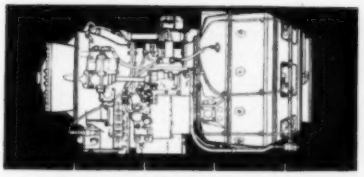
T64 GE have demonstrated that, although a small turbine made to the same standard of quality and efficiency as a big engine is inevitably expensive, it nevertheless makes sound economic sense. In the case of the small T58 it could be shown that the the engine was worth while up to a given flight endurance. For greater ranges the piston engine came back into the picture—from which GE conclude that the pressure ratio of 8.3 was inadequate. The firm became aware of an increasing need for a 2,500 h.p. turboshaft engine with the highest possible efficiency, and accordingly the T64 has been planned to a pressure ratio of 12.5 and very high component efficiencies. The US Navy concurred with GE's conclusions, and early in 1957 the company received a $58m contract for the development (up to 150hr qualification) of turboprop, turboshaft and direct-drive T64s, in both single and twinned configurations, all using the same gas generator.

Although the qualification date for the T64-GE-2 turboshaft engine is ahead of the -4 turboprop, the latter was the first engine to run, dynamometer testing having begun a year ago. The -2 followed in May, and as these words are written the schedule is exactly being met. Guaranteed power and s.f.c. have already been surpassed, and the engine is giving promise of substantially exceeding the design figures without engineering change. One of the contractual requirements is that endurance testing shall be included and GE are completing 10,000hr of cell running (including all the 150hr qualification tests) before the first engines are shipped later this year. These early 50hr engines will be used in the S-64 crane helicopter. The 150hr type tests are scheduled for August (-2) and December (-4) 1961.

LYCOMING *Lycoming Division of Avco, Stratford, Connecticut.*

For many years one of the world's foremost producers of small aircraft engines, Lycoming have for several years developed the free-turbine engines described below. In the piston field, the Company produce Wright Cyclone R-1830s for such aircraft as the Grumman Tracer, Tracker and Trader and Sikorsky and Vertol helicopters. Engines of their own design include the O-360 and O-540 series described below. Among Lycoming missile activities are the design and manufacture of the forward diffuser for the Talos, the nosecone of the Nike-Hercules, the re-entry vehicles for the Titan and Minuteman and solid-propellant rocket chambers for the Polaris and Minuteman.

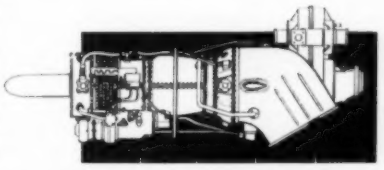
LTC1/T53 Design of this free-turbine unit started in 1952 with a target of 700 s.h.p. A variety of turboshaft and turboprop versions have now been produced, all most successful. Last July, when production contracts totalled $11m, the USAF placed a contract worth $24,746,315, the largest ever awarded the company. The engines were turboshafts for the Army's Bell HU-1 Iroquois and the USAF Kaman H-43B Huskie helicopters, and turboprops for the Army's Grumman AO-1 Mohawk. Two weeks later a $13m contract was placed for flight-testing the L-3 turboprop for the Mohawk and for development of the uprated L-5 (960 instead of 860 s.h.p.). The L-5 is lighter than its predecessors, has a lower s.f.c. and incorporates the company's "universal" concept which allows the same engine to be adapted for helicopters, turboprops or high-speed-output configurations. This engine is now in production for the advanced HU-1B Iroquois, against a contract expected to be finalized at about $7m. The turboprop has been flying in the Mohawk since last April and is shortly to undergo FAA certification. Other T53 applications include the propulsion of several experimental STOL aircraft and a Navy LCVP hydrofoil boat. Under sub-contract to Beech Aircraft, the T53 was to be used in the ground-support unit for the B-70 Valkyrie, but this contract was cancelled last year.



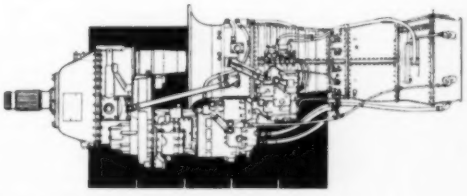
Lycoming T53-L-5 Free-turbine turboshaft engine. Five-stage axial compressor, single-stage centrifugal compressor, annular reverse-flow combustion chamber with 11 vaporizing burners, and single-stage compressor and power turbines. Diameter, 22.9in; length, 47.6in; dry weight, 485lb; max rating, 960 s.h.p. at 6,610 output r.p.m. with s.f.c. of 0.696.

T53-L-3 Turboprop version. Overall length, 58.9in; equipped dry weight, 530lb; max rating, 960 s.h.p. (1,005 e.h.p.) at 1,700 output r.p.m. with s.f.c. of 0.687.

Lycoming T55-L-5 (not illustrated) Free-turbine turboshaft engine. Seven-stage axial compressor, single-stage centrifugal compressor, annular reverse-flow combustion chamber with 14 vaporizing burners, single-stage compressor turbine and two-stage power turbine. Overall diameter, 24.25in; overall length, 44in; equipped dry weight, 570lb; max rating, 2,200 s.h.p. at 14,500 output r.p.m. with s.f.c. of 0.595.



General Electric T58-GE-6 Free-turbine turboshaft engine. Ten-stage compressor with variable inlet guide vanes and succeeding three stator rows, annular combustion chamber with 16 injectors, two-stage compressor turbine, single-stage power turbine and reduction gear at rear end. Basic diameter 16in; height as depicted, 27.3in; basic power-section length, 59in; length as depicted, 71in; dry weight, 250lb or 325lb with reduction gear; max rating, 1,024 s.h.p. (1,050 without reduction gear) at 19,500 power-turbine r.p.m. with mass flow of 12.4lb/sec and pressure ratio of 8.3:1; max cont, 875 s.h.p. with s.f.c. of 0.69; the T58-GE-8 is uprated to 1,250 s.h.p.

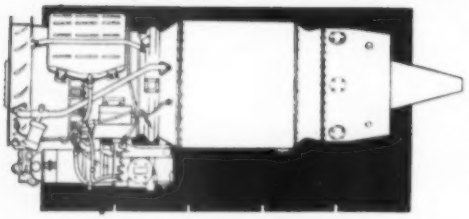


General Electric T64-GE-4 Single-shaft free-turbine turboprop. Fourteen-stage compressor with seven variable stators, annular combustion chamber with 12 nozzles, two-stage compressor turbine and two-stage free power turbine driving remote two-stage epicyclic reduction gear. Width, 29in; height, 36in; length, 113in; dry weight, 1,079lb; max rating, 2,570 e.h.p. at 13,600 (1,150 output) r.p.m., with s.f.c. of 0.522 (net thrust, 565lb); corresponding mass flow and pressure ratio, 25lb/sec and 12.5:1; normal rating 2,230 e.h.p. with s.f.c. of 0.529; 85 per cent cruise rating (constant turbine temperature) at 20,000ft at 370kt, 1,270 e.h.p. with s.f.c. of 0.444.

T64-GE-2 Turboshaft engine. Width, 24.75in; height, 30.4in; length, 91in; weight, 854lb; max rating, 2,650 s.h.p. at 5,200 output r.p.m. with s.f.c. of 0.506; 85 per cent cruise rating at 15,000ft and 100kt, 1,535 s.h.p. with s.f.c. of 0.496.

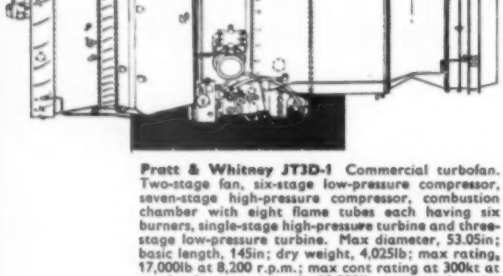
LTC4/T55 Identical in configuration to the LTC1, the LTC4 is slightly larger and approximately twice as powerful. Unlike its predecessor it was initially sponsored by the USAF as a turboprop, Lycoming receiving the development contract for the T55-L-1 in June 1954. In December 1957 the L-1 completed its preliminary flight rating test at 1,600 s.h.p. becoming the most powerful American free-turbine. Nevertheless, the most important T55s

Aero Engines 1960



Pratt & Whitney JT12A-6 Commercial turbojet. Nine-stage compressor, annular combustion chamber with eight flame tubes and two-stage turbine. Overall diameter, 21.9in; max height, 27.8in; length as depicted, 74.2in; dry weight 430lb bare; max rating 3,000lb with s.f.c. of 0.950; max cruise, 2,140lb with s.f.c. of 0.890.

JT12-A-20 (J60-P-1) Military turbojet with afterburner. Overall length, 126in; dry weight, 651lb bare; max rating, 3,900lb with s.f.c. of 2.30 or 1,800lb at M0.9 at 35,000ft or 3,650lb at M2.0 at 35,000ft.



Pratt & Whitney JT3D-1 Commercial turbofan. Two-stage fan, six-stage low-pressure compressor, seven-stage high-pressure compressor, combustion chamber with eight flame tubes each having six burners, single-stage high-pressure turbine and three-stage low-pressure turbine. Max diameter, 53.05in; basic length, 145in; dry weight, 4,025lb; max rating, 17,000lb at 8,200 r.p.m.; max cont rating at 300kt at sea level, approximately 10,000lb; estimated cruise rating at 36,000ft at 500kt, 4,000lb with s.f.c. of 0.79.

are turboshaft engines for helicopters. Sponsored in the autumn of 1957, these have since evolved very successfully from an initial T55-L-3 rating of 1,850 s.h.p.

During the first half of 1959 bench running of the L-3 indicated that this rating was conservative. On May 25 Lycoming were able to announce that an engine rated at 1,940 s.h.p. was to be developed as the powerplant of the big Vertol YHC-1B Chinook helicopter. On August 10 the company announced the successful completion of a 50hr preliminary flight rating test, as a result of which the engine was uprated to 1,900 s.h.p. The test demonstrated a 5 per cent reduction in s.f.c. and a 6lb reduction in total weight; the average output was 2,090 s.h.p. and the maximum recorded was 2,160. The following month the L-5 was approved at 1,940 s.h.p., and during further development for the Chinook power was raised until last month it was announced that the L-5 now has a military rating of 2,200 s.h.p., and over 2,500 s.h.p. has been reached on the bench. Deliveries to Vertol should be made in August. This increased rating makes possible a turboprop with a take-off rating of 2,300 s.h.p. and a military rating of 2,150, and growth potential should make possible the achievement of 2,700 s.h.p. with a further reduction in s.f.c. Power/weight ratios on these advanced models will approach 5 h.p./lb.

The L-5 is a high-speed version with an integral oil tank and cooler replacing the front reduction gear. The L-1 turboprop incorporates a 10.24:1 planetary reduction gear mounted centrally within the intake. The hydro-mechanical control system incorporates governors for both the gas producer and power turbine. In the turboprop the power-turbine governor prevents overspeeding in the event of propeller failure while in the helicopter engine the same governor becomes the primary control. Other features are a fuel pump with two elements each capable of supplying the full flow, an annular combustion chamber folded back to provide five layers of steel around the turbine wheels, and an all-steel-bladed axial/centrifugal compressor of robust design.

O-360 Introduced in 1958, these flat-fours are in large-scale production in aeroplane and helicopter versions. The vertical-crankshaft VO-360-A1A (Brantly helicopters) and the horizontal O-360-C2B (Hughes 269A helicopter) received the first type certificate to be awarded by the FAA following the formation of that body last spring. Both are rated at 180 h.p. and weigh 298lb including starter and generator. The basic O-360 is being supplied to Piper, Beech, Mooney, Colonial, Call-Air and several overseas firms, including Saab. A direct-injection O-360 powers the Rheem USD-2 drone.

O-540 Also introduced in 1958 was a family of flat-six units of 540 cu in, including a 250 h.p. aeroplane model and a 310 h.p. vertical helicopter engine. Very large numbers of both have been made, for such aircraft as the Aero Commander, Piper Comanche and Hiller 12E.

PRATT & WHITNEY *Pratt & Whitney Aircraft, Division of United Aircraft Corp, East Hartford 8, Connecticut.* Keenly aware of the fact that they will never again receive orders for thousands of engines at a time, and that their diminishing aircraft markets are being fought for by worthy foemen—especially GE and Rolls-Royce—Pratt & Whitney have nevertheless continued to thrive upon their excellent engineering and great commercial acumen; and at the same time they have put a large foot inside the door to the space age. During the past year the JT3 and JT4 Turbo Wasps have gone into world-wide service in Boeing 707s and Douglas DC-8s. These engines have flown 500,000 hours since scheduled services started in October 1958. They have established numerous route records and demonstrated their ability to perform with reliability at an exceptional intensity of utilization.

It was a clever move on Pratt & Whitney's part to add a front fan to both the small and large Turbo Wasps and so produce engines which, although fundamentally slightly less efficient than the optimized units soon to come from Rolls-Royce, can improve the performance of important military and commercial aircraft by a substantial margin. Notwithstanding the diminished market for military turbojets, new engines in advanced development—one very small, the other very large—can on paper surpass all their competitors. A major share in the design of the small one (the JT12) was entrusted to Canadian Pratt & Whitney, and an entirely new engine by this company is described in the section dealing with Canada.

In the field of rocket propulsion Pratt & Whitney's policy of letting others tread the path first, and of then entering the field with something which can beat the lot, appears likely to achieve its customary success. Merely by concentrating upon the technology of liquid hydrogen, the company stand on the threshold of business which may eventually enable them to surpass even Rocketdyne, acknowledged leader in the field of big liquid rocket engines; but such work falls outside the scope of this review.

More relevant is the continuation of the P & WA nuclear work, which began with USAF study contracts for a nuclear aircraft engine in May 1951. Since our last review a year ago the Navy's Bureau of Aeronautics have awarded the company a contract worth some $2m to develop hardware. It was the Navy's first such contract, and the components are linked with the requirement and authority of that Service to develop a secondary heat-transfer system for an indirect-cycle engine. The contract followed a previous research study for BuAer which established the feasibility of the company's design proposals. Since 1953, Pratt & Whitney Aircraft have also undertaken basic nuclear studies and development work on advanced reactors, under contract to the Atomic Energy Commission. All this work is based at the USAF-owned aircraft nuclear engine laboratory at Middletown, Connecticut.

Although the company's design and production effort remains centred at East Hartford, the new Florida research and development centre at West Palm Beach made an impressive contribution during the past year, handling the advanced JT11 (J58) family and most of the rocket work. Six new test cells were added to the Willgoos Laboratory during the year (this single facility is now valued at $50m), and employment at the start of 1960 was approximately 36,500.

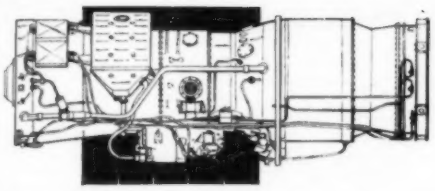
JT3/J57 After manufacturing turbojets of Rolls-Royce and Westinghouse design, Pratt & Whitney roughed out this big two-spool turbojet in 1947. By 1949 the design was complete and production began in February 1953. Since that time more than 17,300 military J57s have been delivered to the US Air Force and Navy, some being manufactured by the second-source established by Ford in Chicago. Last year 1,757 were delivered, and total military hours exceed 6m. Most of the non-afterburning J57s are used in Strategic Air Command B-52s (all versions), KC-135 tankers, and Northrop Snarks, and in Navy A3Ds; in the B-52 they have on occasion reached the brochure overhaul period of 1,400hr. The afterburning fighter engines are usually pulled every 200hr.

A J57 is currently being modified to provide shaft-power for industrial applications. In co-operation with Cooper-Bessemer, Pratt & Whitney have arranged for a J57 to exhaust through a C-B turbine extracting up to 10,500 s.h.p. One assignment will be the cross-country pumping of natural gas, and the engine has been modified to use the gas as fuel.

JT3 commercial Notes on the inception of the airline version of the JT3 were given in our 1959 review. Most engines in current service are of the C-6 sub-type, equipped with a fuel/air (rarely electric) starter, bleed-air anti-icing, bleed-air drive to remote turbo-compressors for cabin pressurization and a combined thrust reverser and multi-pipe final discharge unit. Most operators have recorded cruise consumption for a 707 or DC-8 at 1,680 to 2,080 Imp gal/hr. In the first year of service, ending last October, unscheduled engine changes resulting from "primary causes" (in-flight failure) amounted to 0.21 per 1,000hr, while secondary causes resulted in 1.41 changes per 1,000hr. Unscheduled changes amounted to 12 in 92,264hr flying, and 40 after 300,000hr. Most C-6s are currently operated to a life of 1,000hr, but have to be pulled open at 500hr.

Last September deliveries started on the JT3C-7, distinguished by a weight-reduction of no less than 750lb, chiefly by a major redesign of the carcase. Although in all other respects performance is substantially improved, removal of the water-injection system has cut the average take-off rating by 1,000lb. By the summer of this year the JT3C-10 and C-12 will become available, these being essentially the same as the C-7 but fitted with water injection to restore the 13,000lb take-off rating. List price varies between $150,000 and $160,000.

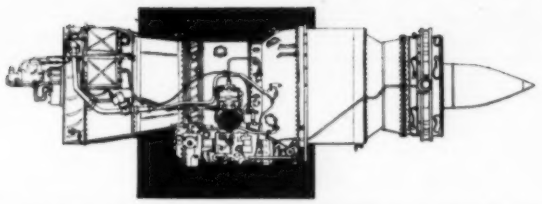
JT3D/TF33 In January 1958 Pratt & Whitney started the detail design of an engine which, although based upon the JT3/J57, incorporates a forward fan in order to handle



Pratt & Whitney JT4A-3 Commercial turbojet. Eight-stage low-pressure compressor, seven-stage high-pressure compressor, combustion chamber with eight flame tubes each having six burners, single-stage high-pressure turbine and two-stage low-pressure turbine. Front-frame diameter, 43in; overall length, 144.1in; dry weight, 5,020lb; max rating, 15,800lb at 8,000 r.p.m. with s.f.c. of 0.78; corresponding mass flow and pressure ratio, 300lb/sec and 12:1.

JT4A-5 Similar except for weight 4,815lb. JT4A-9 Similar except for weight 5,050lb, and max rating 16,800lb with s.f.c. of 0.81. JT4A-10 Similar to -9 except for weight 4,845lb. JT4A-11: weight, 5,100lb and max rating 17,500lb. JT4A-12: similar to -11 except for weight, 4,895lb.

J75-P-2 (JT4A-4) Military engine. Length, 146.4in; weight, 4,960lb; max rating, 15,800lb with s.f.c. of 0.77. J75-P-17 (afterburning JT4A-28): length, 237.6in; dry weight, 5,875lb; max rating 24,500lb with s.f.c. of 2.15. J75-P-19W (afterburning and water injection), length, 259.3in; dry weight, 5,960lb; max wet rating, 26,500lb with s.f.c. of 2.2.



Pratt &JWhitney JT3C-6 Commercial turbojet. Nine-stage low-pressure compressor, seven-stage high-pressure compressor, combustion chamber with eight annular flame tubes each having six burners, single-stage high-pressure turbine and two-stage low-pressure turbine. Max diameter of carcase, 38.88in; max height of engine, 49.2in; length as depicted, room temp., 138.64in; dry weight, 4,234lb; max rating, 13,000lb (s.f.c., 0.90) at 8,000 r.p.m. with water, or 11,200lb dry; corresponding mass flow and pressure ratio, 180lb/sec and 12.5:1; max cruise, M0.85, 4,850lb (s.f.c., 0.963) at 20,000ft, 3,220lb (s.f.c., 0.923) at 35,000ft.

JT3C-7 Max diam, 38.8in; max height of engine, 48.9in; length, 136.77in; dry weight, 3,495lb; max rating at sea level, 12,000lb (s.f.c., 0.785) at 8,000 r.p.m.; max cruise, M0.85, 5,350lb (s.f.c., 0.957) at 20,000ft, 3,550lb (s.f.c., 0.909) at 35,000ft.

JT3C-2 (J57-P-43W) Military engine. Max diam, 28.6in; max height of engine, 49in; length with tailcone, room temp., 167.33in; dry weight, 3,840lb; max rating at sea level, 13,750lb (s.f.c., 0.95) at 8,000 r.p.m. with water.

an airflow 150 per cent greater and reduce the mean jet velocity. Design of the fan was facilitated by the company's work on the J91, the huge but defunct turbojet conceived as the engine for the USAF closed-cycle nuclear programme. A two-stage fan was evolved, with blades some 16in long and of narrow chord, supported by a shroud about two-thirds of the radius from the hub to the tip. As a result of its advanced design this fan is relatively light, and, although having but two stages, has replaced the first three stages of the original l-p. compressor. At the same time, the l-p. turbine has been modified to provide the necessary increase in shaft power by having its second-stage enlarged and a third stage added, making four turbine stages in all. Here again a defunct engine (the T57 turboprop) provided valuable experience on suitable slender blading. Designated JT3D, and sponsored by the Air Force as the TF33, the resulting engine is claimed to retain 90 per cent of the parts of the basic J57, yet gives 52 per cent more take-off thrust with 15 per cent better s.f.c.

Extensive tunnel-testing led to an installation in which the fan air—giving about half the total thrust—is discharged on either side by way of a short duct. Pratt & Whitney emphasize the excellence of this duct, from the viewpoints of installed drag and weight. Nevertheless it has penalties, and considerable effort has had to be applied to overcoming the problems of sonic buffeting by the jets on the flanks of the nacelle. Moreover, full thrust reverse has demanded a complex arrangement involving multiple jacks and shutters on both the lateral ducts, as well as a reverser for the main hot jet. These devices are absent in the much simpler military TF33, and in DC-8s Douglas are going to use a full-length by-pass duct, which will allow full reverse to be accomplished by two shutters.

Bench-running in the Wilgoos laboratory began in the autumn of 1958 and four engines had logged almost 300hr by the end of that year. The first prototype JT3D-1 was flight tested last summer, and by January had been evaluated over its full range of power at altitudes up to 45,000ft. The commercial JT3D-1 has been bought by five airlines, both for new aircraft and conversions, and costs about $197,000. The Air Force has chosen the TF33-P-1 as the powerplant of the B-52H, and the first engine was recently delivered to Boeing at Wichita. Certification testing is near completion, and commercial deliveries are due to start in July. Succeeding the JT3D-1 is the D-3, with a rating of 18,000lb, and due for delivery in June 1961.

JT3D-9 Its "JT3" designation is almost the only point of similarity between this completely new powerplant and its predecessor. Essentially it is a by-pass engine to the Rolls-Royce formula. Although the existing JT3D fan appears to be retained almost unchanged, the low-pressure spool now consists of at least four stages to give a higher fan pressure. The work-split between the spools has been brought more into line with Rolls-Royce practice and a much higher proportion of the total flow passes down the entirely new high-pressure line. By-pass ratio is not more than about 1.1, and the fan air is all ducted aft to a concentric aft nozzle. Design rating is of the order of 21,000lb, and further development is expected to lead to a wet rating of 24,000lb by 1964. The D-9 is at present a paper engine, but Pratt & Whitney are exceedingly anxious to turn it into hardware.

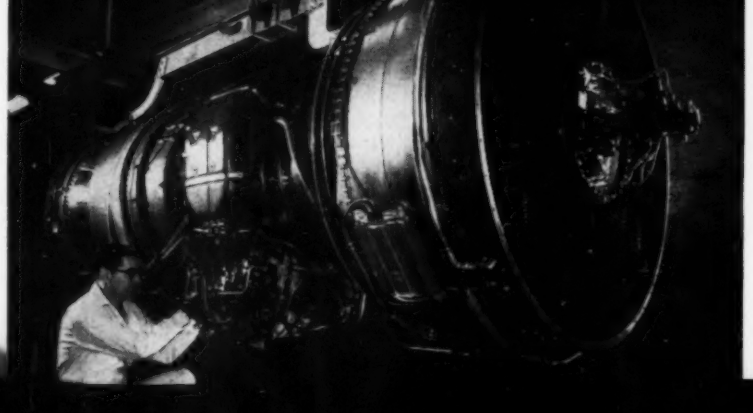
JT4/J75 To a time-scale three years later than that of the JT3, Pratt & Whitney evolved the JT4 as a natural outgrowth to meet the propulsive requirements of the larger first-generation supersonic aircraft of the USAF and Navy. In order not to be inferior in specific weight, the JT4 had to surpass its predecessor in many points of design. For example, the first four compressor stages have a lower hub/tip ratio to handle a substantially increased airflow. Like the JT3D, the longer blades are not much heavier, the stubby fir-tree blades of the JT3 giving way to slender pin-jointed blades of titanium alloy—and one stage was discarded.

In retrospect it can be seen that the military J75 was developed just in time to achieve reasonable production, and total deliveries are likely to exceed 1,000. Last year 308 were delivered, almost all of them J75-P-17 and P-19W afterburning models for the Republic F-105 and Convair F-106. About 20 non-afterburning J75-P-2s were delivered for the three Martin P6M-2 SeaMasters. Total flight time is unlikely to exceed 50,000hr on all military engines. Some endurance testing, possibly amounting to 1,000hr per powerplant, has been achieved by the USAF with J75s mounted on the outboard pylons of the XB-52.

JT4 Commercial Most of the Boeing 707s and Douglas DC-8s so far purchased will be powered by the JT4; in fact, production of this engine is likely to exceed that of the military J75. Although the first airline JT4s are much less powerful than the contemporary Rolls-Royce Conway RCo.12, appreciably heavier and slightly inferior in achieved fuel consumption, they have achieved greater commercial success. First version to enter service was the JT4A-3, 323 of which had been delivered by December 31. An engine of this general type was installed in the No. 2 position of the original Boeing 367-80 in December 1957 for basic testing of the complete powerplant of the 707 Intercontinental. In addition, Pratt & Whitney have attempted to make up for lack of military experience by subjecting individual engines to intensive testing, and have built up at least 5,000hr on one powerplant during simulated airline operations on the bench to an overhaul period of 1,000hr.

From this basic commercial powerplant Pratt & Whitney are evolving a series of airline engines to three main levels of thrust. Moreover, at each level of thrust there are two series of powerplants, one 205lb lighter as a result of a switch to titanium throughout the l-p. compressor rotor and for the first three stages on the h-p. spool, at an appreciable penalty in cost. The lightweight version of the A-3 is the A-5, already in production. Later this year deliveries will begin on the A-9, with improved materials in the first two turbine stages in order to run hotter and give 1,000lb more average thrust. The more advanced A-11/12 series will be rated at 17,500lb average thrust, and are due for delivery some time next year. On January 1 a total of 640 JT4s of all types remained to be delivered, making a total commercial procurement of 862 engines so far. A typical capital cost is $210,000.

Last month Pratt & Whitney Aircraft shipped the first four prototype TF33-P-1 turbofan engines to Boeing's plant at Wichita, Kansas. Commercial JT3D-1s will follow during the summer of this year



JT4D Encouraged by the success of the JT3D Pratt & Whitney hope to sell a front-fan version of the JT4. Preliminary designs have been made on a 62.4in-diameter powerplant with the same cold/hot ratio as the JT3D and on a cheaper unit incorporating a JT3D fan. The latter, designated JT4D-3, promises a reduction of 8 per cent in cruising s.f.c. compared with the JT4A-3. In contrast, the optimum JT4D-1 promises an improvement of 15 per cent; but the evolution of its fan, with its tremendous blades, must pose severe design problems and would cost a great deal. It is doubtful that Pratt and Whitney will ever make it unless considerable production can be guaranteed by acceptance of the JT4D-1 as the powerplant of the big cargo aircraft needed by the USAF and MATS.

JT8/J52 Originally designed to a Navy requirement, and matched to the Douglas A4D-3, this engine moved ahead slowly following the cancellation of that aircraft. It became a major programme only in late 1957, when it was selected as the powerplant of the North American GAM-77 Hound Dog missile. In the same year it was chosen for the Grumman A2F twin-engined, carrier-based attack aircraft.

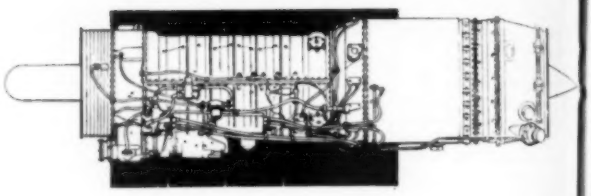
Essentially the JT8 is a scaled-down JT3, although it appears to have an additional flame tube. The original A4D-3 engine was the J52-P-4, rated at 7,250lb dry with s.f.c. of 0.8, and at 10,000lb with afterburner. For the Hound Dog the powerplant incorporates a sophisticated supersonic intake and a plug-type nozzle, in order to match the engine precisely to the flight profile programmed into the missile guidance system. The Hound Dog engine is rated at 8,000lb, and can assist the take-off of the parent aircraft. For the A2F, which should fly within the next week or two, a somewhat different J52 has been evolved under a BuAer development contract for $23.5m placed last July. Components of the JT8 are used in the JTF10 (*q.v.*).

JTF10 Pratt & Whitney may be waiting for someone to buy this attractive engine before they put much of their own money into it. It is a high-compression two-spool turbofan designed for short- and medium-range transports, and STOL aircraft. It should also suit the A2F and winner of the Missileer contest. The commercial configuration incorporates a by-pass duct which takes the fan air round to a single reverser and propulsive nozzle. Originally the JTF10 was intended as the powerplant of the Douglas DC-9, and it was scheduled to run last December, for certification in July 1962.

JT11/J58 Although it is still without any firm application, this impressive turbojet is being financed by the Navy at a high rate. All details remain classified, but much can be deduced.

From the outset its design has been matched specifically to flight at over M3, and it is therefore a single-shaft engine of modest pressure ratio, but capable of accepting an enormous airflow with very great ram pressure and temperature. Between the third and fourth compressor stages is a bleed-system, consisting of circumferential shutters sealed by a valve system operated by three fuel-rams. Extensive running has taken place on outdoor stands at the research and development centre at West Palm Beach, Florida. A high proportion of the total bench time has involved fuels other than JP-4 or -5, and runs have probably been made with boron-based fuels in the high-augmentation afterburner. The latter terminates in a con-di nozzle with a diameter appreciably greater than that of the rest of the engine.

Design of the JT11 was completed in 1957, and the first of a number of YJ58s went on to the bench early in 1958. On August 25 of that year it was announced that a 50hr test had been successfully completed, but no announcement has been made since. Most YJ58s currently on test are intended to prove the basic functioning of the engine, although they incorporate production-type accessories including a Hamilton Standard fuel control of advanced design. Last August the US Navy placed a further $11.2m development contract, and Pratt and Whitney describe present progress as "intensive." Contributing to development is the US Air Force, who are on the verge of asking for funds for the Convair B-58C, an "all-supersonic" Hustler powered by J58s.

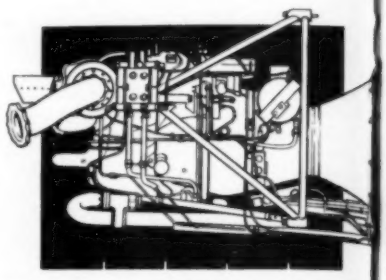


Westinghouse J34-WE-48 Military single-shaft turbojet. Eleven-stage compressor, annular combustion chamber with two concentric rows of burners (total 60) and single-stage turbine. Overall carcase diameter, 27in; max height of engine, 35.5in; length as depicted, 111.5in; dry weight, 1,175lb; max rating, 3,400lb at 12,500 r.p.m. with s.f.c. of 1.048 and mass flow and pressure ratio of 59.5lb/sec and 4.43:1.

JT12/J60 While the JT11 represents the upper end of the new single-spool scale, the JT12 represents the lower end, and is sized to achieve the highest theoretical thrust-weight ratio. Current units achieve a ratio of some 7:1, even when conservatively rated for piloted applications. Much of the initial design was handled by Canadian Pratt & Whitney. Design studies began in July 1957, drawings were released in January 1958, a prototype ran on May 16 of that year, a 50hr test was completed in August 1958 and the engine flew in a pod beneath a B-45 about a year ago. Extensive bench running has been completed on commercial and military examples, with and without afterburner.

Although it appeared on the scene later than its nearest competitors, its outstanding qualities have enabled it to win most of the market. Both transport and combat variants have been ordered, for the North American T-39 Sabreliner, Lockheed JetStar, the Canadair CL-41, and supersonic drones by Fairchild and Republic. First deliveries of certificated engines are scheduled for October. Pratt & Whitney have yet to confirm the unofficial report that they have planned a front-fan derivative.

PT2G/T34 As a result of its 15-year-old design this single-shaft turboprop is no longer commercially competitive, but it is performing sterling service as the powerplant of the Douglas C-133 Cargomaster. Since total production of this aircraft is unlikely to exceed 50, engine contracts are virtually complete, with some 300 delivered. The C-133B is powered by the T34-P-7W, and the commercial variant is the PT2G-7, rated at 7,500 e.h.p. with s.f.c. of 0.63 and a dry weight of 2,870lb.



Reaction Motors XLR99-RM-1 Controllable rocket engine. Single, fixed chamber of basket-tube construction fed by turbopump with liquid oxygen and ammonia. Overall diameter, approximately 43in; length, 85in; dry weight, about 750lb; max thrust, about 50,000lb at sea level or 64,000lb in vacuo with I of about 250, consumption of 19,000lb of propellant (in oxidant/fuel ratio of 1.25:1) in 90sec at full power; corresponding chamber conditions, 3,013°K and 600lb/sq in absolute.

REACTION MOTORS

Reaction Motors Inc, A Division of Thiokol Chemical Corp, Denville, NJ. In 1947 one of this company's first products, the 6000C4 four-barrel alcohol/oxygen engine, enabled the Bell XS-1 to become the first manned vehicle to exceed the speed of sound. The resulting family culminated in the LR11-RM-5, pairs of which have powered the North American X-15 research aircraft during all their early test flights.

From this little assembly line in Denville, New Jersey, are coming the most powerful engines ever designed for an aeroplane. The LR99 (data above) for the X-15 research aircraft has a theoretical maximum horsepower of 500,000, at a flight Mach number of 4.5

LR99 This is the ultimate X-15 engine. The propellants—liquid oxygen and anhydrous ammonia—are unique among aircraft engines and were chosen on the grounds of safety and high specific impulse. Very precise control ensures that no explosive accumulation can build up.

Development has been retarded by problems with the turbopump and valves, until it is now 15 months behind schedule. Bench testing is at last nearing completion and the first engine was delivered to North American last month. Harrison Storms, NAA's chief engineer (Los Angeles Division) says that the LR99/X-15 may fly on May 15.

SOLAR *Solar Aircraft Co, San Diego 12, California.* Several types of highly developed turboshaft engine are now in production at Solar's main plant, and the earlier versions are very widely used in all kinds of industrial and marine applications. The only engine designed specifically for aircraft propulsion is the diminutive unit described below.

Titan First announced just over a year ago, the Titan is one of the smallest gas turbines yet built. Compact and light in weight, it is being marketed both as a constant-speed single-shaft engine and as a free-turbine unit with variable output r.p.m. Owing to its small size it has been designed for hand cranking, and full power is attained in very few seconds. The annular reverse-flow combustion chamber forms the lower part of the engine; all exterior surfaces are shielded from the hot exhaust, which is expelled down through a central duct. The compressor and turbine are arranged back-to-back and machined from a single forging, overhung from a shaft supported in a roller bearing and upper ball bearing, both located in cool portions of the engine. The control system automatically regulates fuel flow to maintain output r.p.m., regardless of load.

Sponsorship for the Titan has been undertaken by the Navy, under the military designations of T62 and (variable-speed) T66. The first YT62 ran on the bench in March 1958. By June last year the 50hr preliminary flight rating test had been completed, and last August the engine flew, powering a Gyrodyne YRON-1 Rotorcycle. Flight testing has been singularly successful and another Titan is now mounted in an improved YRON-1, which will be evaluated by the Marine Corps. Ten additional evaluation engines are being made. The T62 is also likely to be produced in quantity for helicopter APUs, rated at 80 h.p. and weighing 59lb. The first vehicle to be powered by the YT66 is a forthcoming VTOL platform.

WESTINGHOUSE *Aviation Gas Turbine Division, Westinghouse Electric Corp, Kansas City, Missouri.* Since 1941 this division of an industrial giant has developed axial turbojets, chiefly under contract to the US Navy. One of their earliest designs, the 24C or J34, has proved to be their only real success; the larger J46 and J40 are now out of the picture and neither of the turbojets produced as a result of the 1953 agreement with Rolls-Royce has found a production application. The latter are the XJ54—virtually a scaled Avon 200—rated at 6,700lb and the XJ81, rated at 1,800lb and used in the Radioplane XQ-4 drone. The agreement with the British company expires next year.

J34 Several thousand of these engines are in service with the US and Canadian navies, chiefly in F2H Banshees. In 1956, when production had ceased, the company received a $26m contract for the development and manufacture of a much improved all-weather model to power the North American T2J-1 Buckeye trainer. Designated J34-WE-46, it has a revised compressor, combustion chamber and accessory arrangement and can operate on either JP-4 or JP-5 fuel.

Last year the company received an $11.35m contract for the production of the engine illustrated. Unlike its predecessors, the -48 has a single-stage turbine, and virtually the entire hot end, including the combustion chamber, has been redesigned to improve reliability and durability. The -48 is now in full production for the Buckeye, equipped with hot-air anti-icing and an air-impingement starter.

WRIGHT *Wright Aeronautical Division of the Curtiss-Wright Corp, Wood-Ridge, NJ.* The trend noted in our 1959 review has continued; once the premier American aero-engine firm, Wright have failed to establish themselves in the gas-turbine field—except by the quantity production of the J65 under Armstrong Siddeley licence—and with the completion of contracts for the Turbo Compound have little flight-propulsion business left. The company are continuing the development of pyrogenic and prefilled liquid rocket engines, and motor cases and nozzles for various solid rockets. Ramjet work stopped with the termination of the RJ47 programme for the Navaho, and development has also ceased on a wide range of ambitious rocket, turbojet, turboprop and turbo-ramjet engines.

Turbo Compound Many thousands of these superb pieces of machinery are in world-wide service with the airlines and military services of many countries. The final variants were the EA series of commercial engines, rated at 3,400 h.p. for take-off, and the military R-3350-32W (for example) rated at 3,700 h.p. for take-off with fuel derichment and water injection. Production of the latter is continuing in small batches for the final Lockheed P2Vs and Canadair Arguses.

J65 Some 13,000 of these derivatives of the Sapphire have been made under licence from Armstrong Siddeley Motors. Typical is the J65-W-18, weighing 3,482lb with afterburner. With the latter in operation the rating is 10,500lb with s.f.c. of 2.2; military rating is 7,450lb with s.f.c. of 0.93 and at M 0.9 at 36,089ft normal thrust is 2,350lb with s.f.c. of 1.13. The ultimate J65 is an improved model used in the Douglas A4D-2N Skyhawk.

RC engine Late last year Curtiss-Wright announced their association with the NSU Werke of Western Germany in the development of the Wankel rotating-combustion engine. Without Government support, and writing-off development as it takes place, the American company are concentrating on engines of 100 to 700 h.p., but eventually will explore the range of 5 to 5,000 h.p. In addition to all kinds of surface applications they state that the engines will be suitable "for commercial aircraft including VTOL aircraft with range up to 1,000 miles." Production is scheduled for 1960.

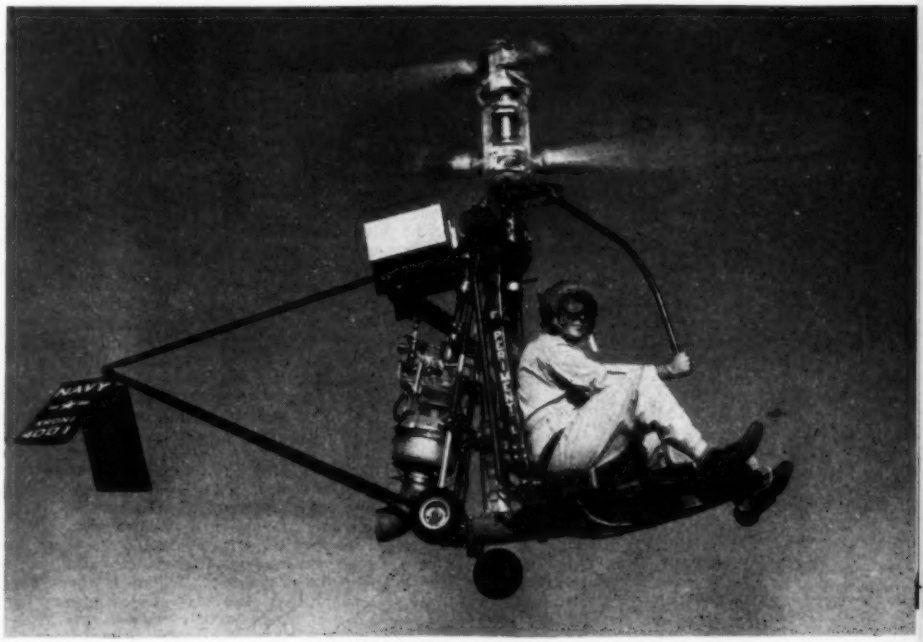
USSR

Virtually no new information has come out of the Soviet Union during the last year to supplement the comprehensive round-up published in our 1959 review (March 20). The following notes summarize the more important powerplants.

Turbojets Largest engine in service remains the prolific family based on the M-209. A single-spool engine, it is simple in configuration; a cutaway drawing appeared in our issue of July 26, 1957. At least 8,000 are in service with the Tu-16 and "Bison" bombers, at ratings between 18,000 and 20,500lb. A variety of commercial engines, designated RD-3, are in use at similar ratings in the various versions of Tu-104 airliner. Now in wide service is the slim axial single-shaft engine reported to be designated VK-5 or M-205 and used in the Yak-25 and Mig-19 twin-engined fighters; dry ratings have been given as 8,690 and 8,818lb.

Turboprops Since last summer A.G. Ivchenko's AI-20 single-shaft engine of 4,000 h.p. has been in Aeroflot service with both the An-10A and Il-18. Also going into passenger-carrying service is the great 12,000 s.h.p. Kuznetsov NK-12, powerplant of the Tu-114. Small numbers of the NK-4 are in use in early Il-18s, and the same designer has produced several larger engines, one of which is the 5,100 s.h.p. unit fitted in the An-4 cargo aircraft. As the powerplant of the Mi-6, the world's largest helicopter, the TB-2BM has now been developed to its design power of 4,700 s.h.p.

The Solar Titan is possibly the smallest and lightest self-contained aero engine currently flying. As installed in the Rotorcycle (below) it weighs 52lb, and has an overall diameter of only 12in



AIR COMMERCE

Think of a Mach Number . . .

THOSE who had thought that the just-supersonic M-wing airliner suggested by the December 1956 Government committee was a dead canard must have had a surprise from M. B. Morgan's paper, read in London yesterday, March 17.

Mr Morgan, who is Scientific Adviser to the Air Ministry, was giving a Royal Aeronautical Society main lecture on *Supersonic Aircraft—Promise and Problems*. In his written paper he said that M1.2 was a natural development for present and projected subsonic jets; a rise to such a speed for medium-range aircraft was inevitable. Over stages of about 1,500 n.m., current advances in aerodynamic knowledge of sweepback would allow cruising speeds to rise to this Mach number without "any large increase in operating costs." But speeds greater than 1.2 were unattractive with a mixed pattern of routes of 1,500 n.m. and less.

Again, Mr Morgan had some shocks in store for those in his audience who regarded Mach 3 as a *sine qua non* for transatlantic cruise. He showed that a reasonably economic aircraft for the London - New York stage length might be evolved to cruise at M1.2, although he thought that, because the technical difficulties "of producing an aircraft at the lower end of the 1.8 to 3.0 region are comparable," there was "no strong case" for the M1.2 transatlantic machine.

The M1.2 to M1.8 region was unattractive, but in the region between M1.8 and M3.0 potentially economic aircraft were possible. Nevertheless, it was M2.0 that Mr Morgan suggested as the cruising speed which might be the natural "fit" for a long-range transport—fast enough to reap the benefits of high speed on engine and aerodynamic efficiency, but not so fast as to run bull-headed into kinetic heating problems.

"Long slender" body shapes carried you, said Mr Morgan, to Mach numbers over 3.0, but the big problem once M2.0 was exceeded was kinetic heating. It could be overcome and passenger appeal for Mach 3.0 was high, but it was all for a ¾hr cut in airborne time. Once steel was adopted instead of light alloy, there was every inducement to approach Mach 3.0, in spite of greater development costs and uncertainty in direct operating costs. Weighing up M2.0 versus M3.0 would demand nice judgment—centering around markets, timing and costs.

It is cheap to go fast, Mr Morgan had said earlier; ideas that speed is expensive are fallacious; as each successive family of aircraft has flown higher and faster there has been a reduction in direct operating costs. In view of this, his audience might have been pardoned for thinking his Mach number estimates erred on the side of caution. The all-steel supersonic aeroplane—in the shape of the B-70—is now being built, and the relish with which US manufacturers have approached the supersonic airliner problem is good reason to suppose that the more difficult step may be the first to be tackled.

There may also, as has been suggested on these pages before, be good reasons for avoiding a head-on US-UK competition over a Mach 3.0 transatlantic airliner, and there are even better reasons for the UK industry not building too slow. But the authority of Mr Morgan's judgment seems again to point the way for a British design that in his paper he did not consider—a type for medium ranges (rather greater than that critical figure of 1,500 n.m.) and cruising at an attractive M2.0. This seems to be a particularly happy combination of speed and range to which we might turn our development endeavours. A.T.P.

COMETS FOR THE SHEIKH—

AS this page goes to press it is confirmed that the Treasury are likely to approve the arrangement whereby BOAC will underwrite the instalments on MEA's £5¼m order for four Comet 4Cs (plus an option on a fifth). If the Chancellor's approval had not been forthcoming not only a Comet sale would have been lost; according to MEA's chairman, Sheikh Najib Alamuddin, his association with BOAC would again have been in jeopardy.

The Sheikh had explained last week that, unless approval of his Comet 4C order was forthcoming by Tuesday, March 15, he would "have to go elsewhere," for Caravelles or Convair 600s.

Asked whether he could obtain delivery of Caravelles or Convair 600s as quickly as he could of Comet 4Cs [from December 15], Sheikh Najib hinted that MEA would operate either Caravelles or Convairs on lease—"if MEA severs its association with BOAC, it would be an opportunity for Air Union to get a strong foothold in the Middle East." Asked whether the Swissair/SAS consortium might be the source of Convair 600s, he declined to comment.

Asked to name the other Arab airlines which he had said were likely to purchase Comets if MEA did so, he said that Misrair might buy more, and that Iran, Saudi Arabia, Turkey, Iraq and a group of Kuwaiti operators also might buy the aircraft. He predicted a total requirement for 30 Comets in the Middle East.

There was, he said, a clause in the contract with de Havilland which made provision for the purchase of D.H.121s in part-exchange for Comets. He did not suggest that this was a firm undertaking but "a highly likely development."

The only question that the Sheikh did not answer in the context of the Comet was the amount of the down-payment and the size and period of the subsequent instalments. To reveal this, he said, might prejudice de Havilland's future Comet sales. But he said that the BOAC guarantee of MEA's Comet purchase covered only the instalments, and that the complete price of the contract (about £5¼m) would be paid by MEA. The reason why BOAC had to guarantee the MEA order at all was because this had been asked for by de Havilland. Purchases could have been guaranteed by the Export Credits Guarantee Department, but at a further cost of about £100,000 in interest (see opposite).

—FOR US CERTIFICATION—

ONE of the conditions on which the Mexican airline CMA ordered three Comet 4Cs last October was that they should be certified by the FAA. The American authority has not yet awarded the Comet 4C a certificate of airworthiness, but is expected to do so when the third aircraft—which will incorporate the few necessary modifications—is delivered in the near future. Meanwhile, the first Comet 4C was delivered to Mexicana in January, and the second last month. Mexicana is 42 per cent PanAm-owned.

—AND FOR MR ONASSIS

THE appearance in the latest issue of the *British Register of Civil Aircraft* of a tenth Comet 4B registered in the name of BEA prompts again the important question of principle: Does BEA's "consortium agreement" with Olympic involve a State corporation in the purchase of equipment for a foreign company?

BEA originally ordered six Comet 4Bs; when the agreement between Lord Douglas and Aristotle Onassis was signed on July 20, 1959, a seventh was purchased. At the same time it was announced by de Havilland that Olympic had "decided to buy" the Comet 4B and would take delivery of two early in 1960.

To *Flight's* inquiry whether these aircraft would be bought by BEA, a spokesman for the corporation said that BEA would act as "purchasing agents" (*Flight*, August 21, 1959).

Then, in the House of Commons on February 1, Sir Arthur Vere Harvey asked the Minister whether he would state the terms on which Comets were being supplied by BEA to Olympic Airways. Mr Rippon, Parliamentary Secretary, replied that it would be "contrary to normal practice to disclose the terms of this contract." Sir Arthur then asked why there was so much secrecy about what should be a normal commercial matter. Mr. Rippon replied: "This is a normal commercial matter. The arrangement is part of a commercial agreement between BEA and Olympic. It would be neither in BEA's interest nor in the national interest to publish details of such matters." Sir Arthur Harvey finally asked whether the Minister was aware that there were public agencies which undertook this type of deal, such as the Export Credits Guarantee Department—"an operating industry like BEA is not there to sell aircraft on the hire-purchase system."

The question arises again with the publication of the March edition of the *British Register*. This ARB publication shows three Comet 4Bs registered in the name of BEA *in addition* to the seven which are the subject of the publicly announced contract between the corporation and de Havilland, and which are currently being delivered. The additional three are registered G-APYC (c/n 6437), G-APYD (c/n 6438) and G-APZM (c/n 6440). A BEA spokesman confirmed that these three aircraft are for Olympic Airways; he was unable to make further comment.

In the absence of further information, it must now be assumed that another Comet 4B is being bought by, or for, Olympic; and that all will be British-registered in the name of BEA.

One of the few matters to which the corporation's policy of "full information" does not apply has always been that of pool agreements with foreign operators. A fair case can be made for the argument that disclosure of information on traffic and revenue-sharing would not be in the public interest. But when an arrangement involves the purchase of aircraft for a foreign pool partner, as is suggested by the facts available in respect of BEA's consortium agreement with Olympic Airways, the Minister is unlikely to be surprised if he is pressed for more information.

AIR COMMERCE . . .

THE TRANSAIR DC-3 ACCIDENT

THE report* on the accident to the Transair Dakota G-AMZD which crashed in Spain on August 19 last year on a return flight from Barcelona is one of the briefest to reach this office. Compiled by the Spanish director-general of civil aviation, it is published in this country by the Ministry of Aviation without further comment.

Unusually in an accident report, no examination is made of the loading records of the aircraft, the number of hours it had flown or the competency and licensing of the crew; it is to be presumed that the investigators considered the cause to be self-evident.

G-AMZD took off from Barcelona Airport during the afternoon of August 19 on a VFR flight plan for Gatwick. On board were 29 students and a crew of three. Except in the area of the 5,500ft-high Montseny Peak, which was enveloped in cloud, the weather was good. The report notes that had the aircraft been flown to the right or the left of the peak, it would have remained in clear weather, but it did not do so and 19 minutes after take-off—while "on a slightly ascending course"—it crashed into Montseny, catching fire on impact. All those on board lost their lives.

The pilot should not have entered cloud, says the director-general, without first advising Area Control that he wished to change to IFR, when he would have been directed to continue his climb towards Bagur and Cabo Creus and from there would have headed for Gatwick. This he did not do, "nor was he flying at the safe altitude necessary for crossing the range. . . . It is to be presumed that the pilot entered the clouds unaware that a mountain . . . lay ahead of him."

The report gives as the cause of the accident an infringement of "the regulations and instructions which are in force for flights over national territory or the International Standards which are in force in Spain."

THE "STRATOEXPRESS IS OK"

SOON to be introduced on the London - Prague route is the Tu-104A, named "Stratoexpress" by its operators CSA. Flight time will be 100min, and the aircraft will be furnished with 16 first-class and 54 tourist-class seats.

Until now CSA have operated Il-14s on the London - Prague route, and their pool partners BEA have operated Viscount 806s. Tu-104A frequency remains the same, at two flights a week, and BEA will continue to operate Viscounts.

The Czech airline is of course a member of IATA, and the promotional material issued by its London office is most attractive, if not quite as sophisticated as that issued by its fellow club members. Introducing their aircraft, they stress how much the Tu-104A . . . "is admired for its speed and reliability. . . ." The story continues:—

"The immense power of the two jet engines develop an equivalent of 60,000 h.p., and the clean lines of the aircraft, indicating an aerodynamically perfect design, combine to provide the remarkable flying features of the Tu-104A [which] is still the only jet transport plane to be provided with navigation radar operating both horizontally and vertically. . . .

"The renowned art of the Czech chefs and the smiling efficiency of the staff make a trip by Tu-104A a luxurious and memorable experience . . . your flight is bound to be 'OK'."

Some data are given about the Tu-104A. As this information is the fullest ever to come from an official source, and because some of it supersedes the information published in *Flight's* Commercial Aircraft number (November 20, 1959), we give it here:—

Dimensions: Span, 34.54m (113ft); length, 38.5m (126ft); width of passenger cabin, 3.2m (10.4ft); height of passenger cabin, 2.1m (6.9ft).
Tankage: 33,000 litres (7,260 Imp gal).
Weights: Maximum take-off weight, 75,500kg (166,000lb); landing weight, 64,000kg (141,000lb); maximum payload, 13,350kg (29,400lb).
Performance: Normal cruising speed, 800-950km/hr (490-590 m.p.h.); take-off speed, 275-300km/hr (170-185 m.p.h.); touch down speed, 220-245km/hr (136-152 m.p.h.); range with 8,000kg (17,600lb) payload, 4,200km (2,610 st miles); cruising altitude, 10,000-13,000m (32,800-42,600ft); take-off run, 1,650m (5,410ft); landing run (without braking parachute), 1,540m (5,050ft), (with parachute), 3,540ft.

* *Civil Aircraft Accident—report by the Spanish Director-General of Civil Aviation on the Accident to Dakota (DC-3) Aircraft G-AMZD which occurred on August 19, 1959, on Montseny Peak, Spain. HMSO, price 1s 6d.*

IL-18 DATA—OFFICIAL

INCLUDED also in CSA's recent promotional material are facts and figures about the Il-18, six of which have been ordered by the Czech airline from the USSR. These are the first figures to come from an official source since the Brussels exhibition of 1958, and for the same reasons as those mentioned in the foregoing notes on the Tu-104A, we give them here:—

Dimensions: Span, 37.4m (123ft); length, 35.7m (116ft).
Tankage: 23,700 litres (5,210 Imp gal).
Weights: Take-off weight, 61,000kg (134,480lb); maximum payload, 14,000kg (30,865lb).
Performance: Take-off distance, 1,150m (3,780ft); landing distance, 800m (2,625ft); take-off speed, 220km/hr (130 m.p.h.); landing speed, 190km/hr (118 m.p.h.); cruising speed, 650km/hr (404 m.p.h.); range with full load and fuel reserve for one hour's flight, 5,000kg (3,100 st miles).

TOO MUCH TOO SOON?

"IT is possible," says South Africa's transport minister, Ben Schoeman, "that SAA's 707 service will be run at a loss." He notes that the Boeings *had* to be bought—"if we cannot keep up with other international airways we shall have to get out of world competition altogether. Our only hope is that the volume of traffic in South Africa will increase. I believe the potential is there." D. H. C. du Plessis, the general manager of South African Railways, which owns and controls SAA, said recently that SAA's Boeing 707s would require a 70 per cent load factor. This means that SAA will have to carry the same number of passengers out of Jan Smuts Airport to international destinations as lifted by all carriers at present. This is evidently why SAA are fully behind BOAC in their efforts to introduce economy fares on the route with or without IATA agreement.

OUT OF MOTHBALLS

TWO of SAA's four Constellation 749As, for which a buyer has been unsuccessfully sought since Viscounts were introduced on domestic services 15 months ago, are being returned to service. From April 1 they will be used on the Capetown - Johannesburg run. It is possible also (see *Flight* last week) that they will be used on a new service of closed group flights to the UK in association with the Overseas Visitors Club. Meanwhile SAA's two other Connies remain in mothballs.

CUTTING RED TAPE

THE International Civil Aviation Organization is getting on with the job of encouraging governments to cut at least some of the red tape which causes so much irritation to the airlines and their customers. More than 50 recommendations were proposed by ICAO's facilitation division after it met recently in Rome; these have now been reviewed by ICAO's air transport committee, and they are being sent to the 76 members of ICAO for comments.

The most important recommendations are as follows: (1) Elimination of the passenger manifest; (2) Simplification of the general declaration (the basic document for the clearance of an aircraft by Customs, immigration and health officials); (3) Elimination of visas for tourists and other temporary visitors; (4) Acceptance by states of oral baggage declarations; (5) Elimination of outbound baggage declarations; (6) Abolition of tax certificates; (7) Clearance of inbound cargo on a sampling basis.

The chairman of ICAO's air transport committee, Dr A. Kotaite of the Lebanon, says: "After we have received the comments our committee and the ICAO council will take final action by making those recommendations that are accepted a part of ICAO's *International Standards and Recommended Practices* for facilitation." [Annex 9 to the ICAO Convention.] This, he hopes, will probably take place in May, after which "we shall start to work again on cutting red tape."

Left, one of the satellite terminals proposed for Cologne's new Rhein-Ruhr Airport. A tunnel connects each with the main terminal building

Right, these low-backed, forward-facing Viking chairs are the result of Eagle's modification of the aft-facing units. Weight-saving of 10lb per double chair is achieved; conversion cost, £25.

See also page 391

Capt J. C. Kelly-Rogers (left), deputy general manager of Irish International Air Lines, hands over a cheque to William Makinson, managing director of General Precision Systems Ltd following the signing in Dublin on March 7 of an order for a £100,000 Boeing 720 simulator which will be installed in Dublin by the end of the year

AIR COMMERCE . . .

EAGLE LEASE A BRITANNIA

AS this issue closes for press *Flight* learns that Eagle Aviation have completed negotiations with Cubana for the lease of a Britannia 318. Delivery will be made next Tuesday, March 22. The aircraft, one of four delivered to Cubana last year, will be CU-P668, c/n 13432. The contract calls for a seven-month lease with an option to purchase. Harold Bamberg, chairman of Eagle, tells us that the period of the lease will permit his airline to evaluate the capabilities of the aircraft, and to decide whether the option to buy is to be taken up.

Eagle considered buying a fourth DC-6C, but discounted this in favour of the Britannia. The aircraft is not being bought for any specific purpose; normal commercial commitments for the 1960 season, say Eagle, call for the addition of further fleet capacity.

The company will maintain the aircraft, subcontracting only Check 4s to Bristol Aircraft and Proteus 761 overhauls to Bristol Siddeley.

Financial details of the contract are not available; as previously noted in *Flight*, Cubana have been offering a Britannia 318 for lease through Aircraft Exchange at a monthly rental of $65,000 (about £23,000). Last week the aircraft was offered for outright purchase at a price of $3,435,000 (about £1,225,000).

ARGOSIES FOR BEA—

THE news that BEA are likely to operate the Argosy (*Flight* last week) comes six months after a particular comment by Lord Douglas, the chairman. Answering questions following presentation of the corporation's annual report, he said: "We are mildly interested in the Argosy, and a use might be found for it in a few years time."

Since then BEA have been engaged upon paper studies of the aircraft which (notwithstanding the very big increase in freight capacity that the new Vanguard fleet will offer) have evidently transformed "mild interest" into something much stronger. It is understood that if present negotiations go according to plan the corporation will not purchase the Argosy outright, but will lease three, with an option to purchase, for operation in 1961.

Asked last week whether the Ministry of Aviation would participate in a manner similar to the arrangement whereby they are buying BEA's three Dart Heralds, a spokesman replied that his Ministry was not involved in the corporation's Argosy plans.

It remains to be seen whether BEA will in the meantime co-operate with Armstrong Whitworth in the route-proving which is necessary for completion of the Argosy's airworthiness certification programme. As reported below, the C of A programme is now expected to be completed in June.

—AND FOR TRANS ARABIA AIRWAYS

AS *Flight* goes to press it is learned that Trans Arabia Airways are to announce today, March 18, a firm order for two Argosies. The contract, with spares, will be worth about £1·1m. Earlier this week a spokesman for Armstrong Whitworth confirmed the report; this is thus the first firm Argosy order.

Trans Arabia Airways (*Flight*, January 15, p. 91) are registered in Kuwait and based in Beirut. They have operated scheduled services since September 1959 between Kuwait and Beirut. Two DC-4s are operated, one of them on charter from the UK independent Starways, and DC-6s. Licences to various points in the Persian Gulf and neighbouring Arab states have, it is believed, been granted, and will presumably be Argosy terminals after delivery (this year). One of the owners of Trans Arabia is Sheikh Duaij Al Saman Al Sabah, a relative of the ruler of Kuwait. The general manager is Capt R. G. Gibson, formerly of ANA.

It is appropriate to record here the news that the six Argosies now flying have completed more than 1,000 flying hours, the actual figure last weekend being 1,010. The certification programme—notwithstanding the fact that it has been dogged by bad weather—is proceeding well, and a C of A is expected in June after an intensive route-flying programme has been completed.

"SLUSHGUARDS" FOR THE COMET

IT became known last week that, but for the exceptional airmanship of Captain Peter McKeown and his crew, a Comet 4B of BEA might have been involved in a serious accident in the course of a proving flight from Copenhagen four weeks ago. A few moments after take-off from a slush-covered runway two engines began to run roughly. Captain McKeown shut them down; shortly afterwards a third "rougned up." He started up one of the two shut-down engines again and made a full emergency landing on two Avons. It was found that the engines had been damaged by grit thrown up in the slush from the nosewheels.

The Comet remained at Copenhagen for several days and three engines were changed. No report of the incident leaked out. Modifications to the tread of the nosewheel tyres and the installation of slushguards have, according to a BEA spokesman, subsequently been tested by de Havilland, and will be incorporated in due course. A rapid thaw, he said, had made the depth of slush "quite unusually severe."

Footnote: The Ministry of Aviation last week announced that the independent body appointed in June 1959 to review Captain Thain's representations about the BEA Elizabethan accident at Munich is to hear his representations at a public hearing beginning at 10.30 a.m. on Monday, April 4, at 10 Carlton House Terrace. It will be recalled that Captain Thain contends that the effect of slush on the take-off was not properly considered by the German investigators.

THE HERALD-GO-ROUND

IT seems possible that the Handley Page Dart Herald may soon be able to lay claim to being the world's most demonstrated aeroplane. The second prototype has already visited 44 countries on its 26-week tour of five continents and on March 16 a team under R. S. Sowter, sales manager HP (Reading), was due to be off again.

On this occasion, the fourth international tour, the first production aircraft G-APWA will cover parts of Africa and South America in a 30,000-mile Herald-go-round lasting from March 16 until May 24. In particular the team will visit and give demonstrations at Accra and Lagos in March, cross the South Atlantic on long-range tanks on April 3, and call at Rio de Janeiro, Sao Paulo, Porto Allegre, Buenos Aires and Montevideo during April and May.

This fairly leisurely pace (six days at Lagos, 16 days at Rio, 12 days at Sao Paulo) is intended to give time for demonstrations and discussions with a number of airlines who have previously expressed interest. With Mr Sowter in South America will be R. H. Johnson, recently appointed HP resident salesman in Brazil, and the aircraft will be flown by Captain R. Shilton, who was seconded from Silver City to assist with airways procedures for the Australasian tour.

But with an already prolonged series of tours producing no announcement of orders other than for three aircraft for BEA to be purchased by the MoA, the question arises as to how long these demonstrations will continue. Until one or more orders is obtained? As long as interest lasts? Until a fixed financial allotment for demonstrations is exhausted? These are questions upon which Handley Page can make no comment; the answer, as with results of the forthcoming tour, must be "wait and see."

PILOTS AND THE MERGER

THE safeguarding of personnel interests is the job of the unions, and the statement recently issued by the British Air Line Pilots Association is a notable example of that body's primary trade union function.

When Airwork's operations were taken over by Transair in the spring of 1959 there was dissatisfaction among the crews at the way that job allocations were decided. All Airwork pilots, note BALPA, were declared redundant and many of those not fortunate enough to get posts with Transair had to obtain employment where they could or leave the industry altogether. Many of these pilots, say BALPA, were very experienced, but it seemed that youth came before age.

The merger between Airwork and Hunting-Clan (commented upon last week) has raised similar issues. While welcoming rationalization among British independents, the Association says that it is now determined to see that pilots are selected from the two groups concerned "in a way which will occasion the least disharmony and distress." The inevitability that employment will not be found for all pilots has had to be accepted; it is a function of the increased productivity of modern aircraft. For those who are eliminated from their chosen profession, BALPA asks for a human and sympathetic approach and selection on the fairest possible basis. This attitude is backed, they say, by pilots employed by the corporations—"It may be their turn next!"

Here is the fourth de Havilland Comet 4 for Argentina's national airline awaiting collection at Hatfield last week. It was actually delivered on March 8. The fifth is now ready for delivery, and the sixth is "very advanced." Prompt delivery of Aerolineas Argentinas' second batch of three Comets will help to maintain the schedules disrupted by the loss (believed not to be attributable to the aircraft) of two of the original three

VIKING MK 3

IT was inevitable that the new so-called WAT curves (weight, altitude, temperature) to which the older transport aircraft on the UK register now have to conform are restricting performance and impairing economics. Hardest hit are the operators of Dakotas and Vikings.

It was inevitable, too, that means would be sought to improve performance in order to restore some of the lost payload-carrying ability in the higher temperatures and airfield altitudes. An example is Transair's Dakota modification, introduced three or four years ago; more recent is Eagle's improvement to the Vickers Viking Mks 1, 1A, 1B and 2. The effect of this new Viking modification is to increase payload—where limited by the new regulations—by 1,200lb-1,400lb in respect of both the take-off and the WAT-curve case.

Eagle Aircraft Services, who are responsible for the modification, call the new Vikings the Mks 3, 3A, 3B and 4. The modification is primarily to the cooling system of the Bristol Hercules 634, certain cylinders in this engine having been found to reach limiting temperature (300° C) before others. The Eagle modification, engineered and agreed with Vickers and Bristol Siddeley, has been granted ARB approval. It greatly improves the uniformity of cylinder head temperatures. Five cooling louvres are introduced in the cowling over the "hot" cylinders, and new baffles and splitters ensure that cooling air passes between every fin.

As a result, the 2,400 r.p.m. used for maximum continuous power can be raised to 2,500 r.p.m. for a period limited to one hour. The modification (EAS/VIK/356 C/M) qualifies the engine for re-rating and Bristol Siddeley have designated the unit Hercules 674. Take-off r.p.m. are limited to 2,700.

Certain other changes are associated with the cooling modification. These include, where not already fitted, the installation of de Havilland propellers Type PD97/446/1 or 2, and the incorporation of Eagle's "anti-gulp" engine modification. The complete modification results in a 90lb weight-saving, or 290lb where Rotol propellers with metal spinners are changed for D.H. propellers. Enquiries should be addressed to the sales manager, Eagle Aircraft Services Ltd, London Airport.

Footnote: Vikings fitted with 36 aft-facing "payloader" chairs offer further scope for payload increases—to the extent of 180lb, or roughly one passenger plus baggage. By turning the chairs round to make them forward-facing it becomes possible to shorten the backs; and an Eagle modification to this effect saves 10lb per double chair. (See photograph on page 389.)

MUCH MORE INFORMATION NEEDED

SECTIONS of the Civil Aviation (Licensing) Bill are quite uncontroversial. No one says that good operating standards should not be required of charter as well as scheduled operators. Nor, when a statute has been stretched as far as is the case with Section 24 of the 1949 Air Corporations Act, can one complain if a Government does something about it. If a law is not to be enforced then it is better to amend it.

The Opposition voted against the Bill on Second Reading on March 2 because of the provisions, or lack of them, in relation to the proposed board. It was the logical thing for them to do since they had always maintained that, given the proper encouragement, the publicly owned air corporations could gain for Britain the maximum share of the world's scheduled passenger and freight air traffic. It has, incidentally, been a fascinating spectacle to watch how the independent operators have hung on to this business by their fingernails. And now, after all the frustrations under successive governments, it seems likely that the arguments will be settled in a technical rather than a political arena.

George Strauss said the Opposition's objections to the bill were twofold. Firstly, the terms of Section 2 were so vague and imprecise that "no one knows what the consequences will be." Secondly, he thought the likely consequence would be to damage the two air corporations in which nearly £300 millions of public money had been invested.

Even the best friends of the bill must admit that there is substance in the first criticism. The Minister himself stated his intentions in relation to the new licensing board in the following terms: (1) the board should be as independent as it is possible to make it; (2) applicants will be given a fair opportunity to obtain licences for new services; and (3) proper protection will be afforded to existing operators. Quite so. The question is how to achieve, or reconcile, these admirable objectives.

The fact is that this is largely an "enabling bill." The administration will be all-important. (To a much greater extent than seemed to be appreciated in the debate, this also applies to the provisions in Clause 1 for an "air operators' certificate.")

Three speakers in the debate made reference to the *Flight* interview with Harold Bamberg, chairman of Eagle Aviation. Mr Bamberg was quoted as saying that everything would depend upon the "interpretation" of the bill. He was, of course, quite right. But he also said something else which bears consideration. He remarked in his interview that "we now need to evolve a new method of measuring airline efficiency. I think a formula can be found which would show whether a low fare is made possible by genuine efficiency or by subsidy or other factors."

There are, of course, many methods of measuring efficiency, and from them one can usually find some figure to bear out any argument. But if experience now makes possible some *new* method of measurement then the board's problems can be simplified considerably. Mr Bamberg was referring to fares; but there are other matters which might well yield to an objective, technical, clinical treatment. There is, for example, the whole question of traffic potential. An applicant for a licence and an objector to the application will both be able to deluge the board with figures to prove their respective cases. Will the board have the benefit of its own sources of information? Will it have any research facilities? Will it have independent means of checking claims and counter-claims? Will it have its own advisors on such issues as diversion of traffic? In short, what kind of secretariat to the board does the Minister envisage? Much will depend upon this if the board is to achieve the independence and authority which is needed.

Mr Sandys said that he had reached no final conclusions about the composition of the board itself, except that its members would be "men of wisdom and experience." His reticence is understandable, but he could be much more forthcoming about other aspects of the board's status, powers, and responsibilities.

If he was pressed a little more on this point of staff it might be possible to form a clearer idea as to what he has in mind when he speaks of an "independent" board. Does he believe that it is possible to decide whether a parallel service is wasteful, or promotional, or stimulating on the basis of statistics? And if so, who is to provide them? Furthermore, if statistically there appears no clear advantage or disadvantage in licensing a parallel service, is the applicant or the existing operator to get the benefit of the doubt? Is the Minister to give any general guidance on such a point as that?

It is relevant to know if the Minister has any longer-term picture of the kind of air transport pattern which he seeks to create. Already he has caused the aircraft industry to reshape itself. He has brought about some changes on the operating side. Does he want this process of merging to proceed? Would he prefer to see operators specializing? The board could influence these matters; is the Minister's intention that it should?

Having changed so much within the short space of six months it is conceivable that Mr Sandys may prefer to leave things entirely to the play of economic forces, and the wisdom of the six to ten aeronautical Solomons whom he proposes to appoint. Nevertheless, there is no reason why Parliament should not ask for much more information during the course of the committee stages of the bill.

FRANK BESWICK

AIR COMMERCE . . .

Misleading Comparisons

IN the current heated discussions on the new Bill a great deal of reference is being made to the US Civil Aeronautics Board and to the Canadian Air Transport Board—just as if they were bodies analogous to the proposed UK Air Transport Licensing Board. This is only partially true, as may be seen from the analysis on page 338 of last week's issue, and this commentary.

FEDERAL legislation in both the USA and Canada is characterized by complex laws protecting the public against the dangers of monopolies—the so-called anti-trust laws. But whereas in the USA Congress has not selected any particular carrier to be its chosen instrument for air transport, in Canada not only is the Minister of Transport empowered to provide air transport services, but Trans-Canada Airlines is the chosen instrument.

Thus the nearest comparison is probably to compare the combination of (Minister + ATB) in Canada with the (Minister + ATLB) in the UK. But since the UK independents are hoping for a degree of competition more similar to the US model than the Canadian model, it is useful to glance briefly at the comparative systems.

United States. In order to escape prosecution for infringing the anti-trust laws, US air carriers require CAB approval of contracts they enter into, pooling arrangements, stock mergers, rates and charges. In order to carry out this enormous task of approval conscientiously the CAB has, and uses, massive powers requiring full disclosure of every facet of an airline's activities. It is safe to say that the UK industry would *not* welcome the degree of control and scrutiny exercised by the CAB—and yet the whole CAB system is dedicated to the proposition that regulated competition is the lifeblood of commerce.

This may be regarded as typical of the American ideal of one force acting as a check or balance to another force in government. The CAB, in fact, controls the major policy and regulates the operations of the whole US air transport industry without removing the right of each carrier to use its own capital and to provide manpower and brainpower within this framework. The results are not free from criticism either by lawyers or businessmen in the USA.

But the CAB is not concerned solely with the economic regulation of air carriers. It can appoint its own staff, co-operate with other government agencies, and even exchange information with foreign governments. Above all, its decisions must be published. The CAB does not simply "approve" of rates. It can fix the rates —including mail pay—and award subsidies.

The CAB also investigates aircraft accidents and may call upon the NASA for assistance. And in the 1958 Federal Aviation Act it was given a new task—that of hearing appeals from the Administrator of the Federal Aviation Agency (which deals with safety) on decisions concerning the grant, suspension, variation or withdrawal of aircrew and other licences, certificates of airworthiness, air carrier operating certificates (inadvertently omitted from the table last week), etc.

Canada. Like the CAB, the ATB can determine its own rules of procedure and has considerable powers to obtain the evidence it needs, to summon witnesses and to make investigations. The ATB also has powers to act in an advisory capacity to the Minister.

The ATB may only issue licences for commercial air services *subject to the approval of the Minister* and it *must* issue licences to TCA to enable TCA to carry out its appointed functions.

BREVITIES

An air services agreement is being negotiated in Prague between Czechoslovakia and Iraq.

Skyways' Hermes G-ALDH suffered a collapse of the starboard undercarriage while landing at London Airport on Tuesday morning, March 8.

BEA's order for six Rotodynes will be completed when BEA has the manufacturers' assurances on certain requirements, "particularly in respect of noise."

Six of the 30 Convair 880s which are on order for TWA may be diverted to Alaska Airlines for service on the Seattle - Fairbanks route in June.

No defects in either the airframe or engines had occurred to the Piaggio P.166 in service with Papuan Air Transport up to the time of the first engine change at 600 hours.

Cambrian Airways are "looking at Viscount 700s" according to their managing director, Wg Cdr M. B. Elwin. They hope to operate them from Cardiff and Bristol to the south of France "within two years."

A third Lockheed Electra has been ordered for delivery in August by Trans-Australia Airlines. Those already in service with TAA are currently achieving an average utilization of more than 11 hours per day.

It is reported from America that New York Airways are "seriously considering" the possibilities of installing Napier Gazelles in their fleet of 10 Vertol 107s, five of which will be going into service in the spring of 1961.

Another carrier which may place additional orders for Fairchild F-27s (the probability that Ozark may do so was mentioned last week) is Quebecair. The airline will probably order at least one more this year and is considering ordering a further six over the next two years.

A letter of intent for three Boeing 720s has been signed by Braniff. If the order is taken up delivery will be in February, April and September of 1961. An option on a fourth for delivery in May 1962 has also been placed. The order is subject to negotiation "of a mutually acceptable definite agreement."

Bookings on BOAC flights between London and New York between February and July are 50 per cent greater than those last year, and reservations on flights from New York to London have risen by 37 per cent. In all, 18,000 more seats have been sold on BOAC's North Atlantic services than at the same time last year.

John Turner-Lashmar has been appointed sales manager for KLM in the UK and Ireland.

The first Electra service to Moscow will be operated by KLM from the beginning of next month. Total dividend declared by the airline for 1959 will be 7 per cent.

Olympic Airways' Comet services between London and Athens have been postponed from April 1 until May 18. A note on the BEA/Olympic Comet 4B deal appears on page 388.

The FAA has ordered all US airlines operating Boeing 707s to inspect the nose gear for cracks. A visual check is to be carried out daily with a magnifying glass and within 20 days a test must be made with an ultrasonic probe.

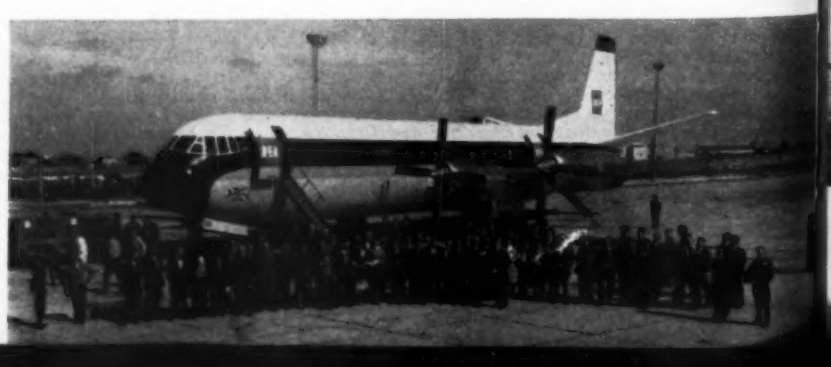
Bookings on BEA domestic flights are said to be at least 20 per cent higher than at the corresponding period in 1959. Particularly popular are the cheap early morning and night flights on the trunk routes between London and Glasgow, Edinburgh and Belfast.

Douglas have established a Caravelle programme management office for co-ordination between Douglas and Sud Aviation. It will be managed by J. J. Dysart, previously assistant superintendent of schedules for the Santa Monica division. Another office will be set up at Sud Aviation's factory at Toulouse.

American International Airways, charter operators based at Burbank, California, have been refused renewal of their first year's operating certificate by the FAA. Violations were said to have covered "just about everything in the book" including general level of aircraft maintenance, pilot qualification, and flight-time limitations. This was the first such action to be taken by the FAA.

BKS have applied to the ATAC to operate a scheduled service to Cork (*Flight*, December 11, 1959) with Dakotas and Ambassadors, and later Viscounts and Avro 748s, from London Airport and/or Bristol and/or Cardiff, from January 1961. An application to fly to Cork has also recently been made by Morton as an extension of its service between Gatwick and Brawdy (*Flight*, February 26).

Blame for the accident to the Avianca Super Constellation which crashed at Montego Bay airport on January 21 has been placed on the pilot. It was said that he adopted a final approach which resulted in a heavy landing and major structural failure. A contributory cause was default of the supervisory and advisory authorities responsible for conduct of flight operations of the airline. The report also said that there was some deficiency in respect of training.



A big load of passengers was carried on one of the Vanguard's current series of proving flights. Here they are, all 104 of them, at the end of a flight to Malta

SERVICE AVIATION

Royal Air Forces and Naval Flying News

Royal Aides-de-Camp

FOUR new ADCs to the Queen have been appointed. Air Cdre H. I. Edwards succeeds AVM R. N. Bateson, who relinquishes his appointment on promotion; Gp Capt W. D. Hodgkinson succeeds Gp Capt P. G. St G. O'Brian on the latter's retirement from the RAF; Gp Capt L. A. Jackson succeeds Air Cdre A. H. McM. Hely, who relinquishes his appointment on promotion; and Gp Capt J. H. Stevens succeeds Gp Capt E. Knowles on the latter's promotion to air commodore.

Conferring with Commanders

A CONFERENCE of all RAF commanders-in-chief at home and overseas was held at the Air Ministry on Thursday and Friday last week. Called by Air Chief Marshal Sir Thomas Pike, CAS since the beginning of this year, it had as its object the discussion of broad strategic problems affecting the Royal Air Force at present and in the future. It also considered operational, organizational and personnel problems affecting the Commands generally. The new CAS intends to confer with Cs-in-C at home at regular intervals and with overseas commanders annually.

FAA Equipment

IN the debate on the Navy Estimates on March 7 the Civil Lord of the Admiralty, C. Ian Orr-Ewing, said: "The Type 12 Whitby class anti-submarine frigates are proving particularly successful. Ten of these will be in service in 1960, and we have decided to exploit their good qualities in an improved and more versatile ship. This improved Type 12 will be known as the Leander class. The hull and steam turbine machinery will be substantially the same as for the Whitbys. The main new features planned are a long-range air warning radar, the Seacat anti-aircraft guided missile, improved anti-submarine detection equipment and a light-weight helicopter armed with homing torpedoes."

Later Mr Orr-Ewing said: "The introduction of new types of aircraft is going ahead steadily. The first Sea Vixen squadron, which formed in July 1959, embarked in the *Ark Royal* last week. The second formed five weeks ago. The gas-turbine-powered Wessex helicopter enters service next month and the first squadron should join the fleet next year."

Peninsular Hunters

BRIEF reference was made on one of our news pages last week to the re-equipment of No 8 Sqn at Aden with Hawker Hunter FGA.9s. A ceremony marking the squadron's conversion from Venoms was attended on Monday last week by the AOC, Air Forces Arabian Peninsula, AVM David Lee. He inspected the eight FGA.9s and two T.7s on the ground at Khormaksar, saw a firing demonstration at the rocket range and in the afternoon watched a fly-past led by the CO, Sqn Ldr R. Knight. No 8 has been "resident ground-attack squadron" at Aden for almost the whole of the past 32 years.

ROTATING-WING JUBILEE

A QUARTER-CENTURY of flying with rotating-wing aircraft is being celebrated by the RAF this year; and with appropriate pride in this jubilee the Air Ministry recently issued a short history of the 25 years' specialist work, compiled by H. J. Cooper of the Information Division. It has been used as the basis for the following account, which is illustrated by photographs from the same source (with two exceptions—the Bristol 192 and Skeeter).

Old Sarum was the first venue for RAF rotating-wing flying, for in December 1934 the School of Army Co-operation there was issued with six Rotas, the name given by the RAF to the Cierva C-30 Autogiros built under licence by A. V. Roe & Co. Subsequently the school ran Rota courses for pilots from AC squadrons and the aircraft (powered by a 140 h.p. Armstrong Siddeley Genet Major) were used in Army/RAF exercises in September 1935. At the outbreak of war the Rotas were supplemented by some civil-owned C-30s and also by C-40s, which had a 175 h.p. Salmson engine and "jump take-off" abilities. The Air Ministry had ordered five C-40s and two of these went to France in 1939 with the BEF. Later in the war the C-30s and -40s were used on radar calibration work, based at Duxford as No 1448 Flt, which re-formed in 1943 as No 529 Sqn and existed until 1945.

The flight had been originally commanded by Wg Cdr (then Sqn Ldr) R. A. C. Brie, formerly chief test pilot of Cierva, who in late 1941 went to the US to investigate using helicopters from British merchant ships for AS duties. This resulted in a Royal Navy order for R-4s and -5s, developed from the experimental Sikorsky XR-4 helicopter. Sea trials were carried out, including an Atlantic convoy in early 1944, and Wg Cdr Brie and Flt Lt F. J. ("Jeep") Cable took the aircraft to Hanworth, where a pilot training school was started. This was the first use of helicopters in the UK. The YR-4s (180 h.p. Warner Super Scarab) were known in the RAF as Hoverfly Is; there were also some R-6s (245 h.p. Franklin), known as Hoverfly 2s. At this time the Royal Navy was investigating the use of R-4s for ASR work, so the RAF formed the Helicopter Training School at Andover (commanded by Sqn Ldr Basil Arkell) to train Army AOP squadron pilots on R-4s. Other experimental work was done on telecommunications and radar, and in bad-weather reconnaissance. Eventually the RAF handed over their R-4s and R-6s to the Army and Navy, retaining one R-4 in the King's Flight.

JEHU (the Joint Experimental Helicopter Unit) was formed at the beginning of 1954 and lasted until the end of last year: in it, the RAF and Army worked together on problems affecting the military application of helicopters. It has now become No 225 Sqn.

Much of the RAF's helicopter experience in recent years has been gained in overseas theatres like Malaya and Cyprus. The Westland-Sikorsky S-51, a development of the R-5 and the first helicopter with an operational capability, came into RAF service in 1950 as the Dragonfly HC.2 and in April that year the first were

Past and future: A Rota (Avro-built Cierva C-30) of No 529 Sqn in the early war years and a Bristol 192, the twin-rotor heilcopter which is shortly to enter RAF service, seen carrying a Bloodhound

SERVICE AVIATION...

sent out to Singapore. There the Casualty Evacuation Flight was formed at Seletar, initially with three Dragonflies, under the command of Flt Lt K. Fry. This was the first British operational unit equipped with helicopters. The flight, which later moved to Changi, took part in a great variety of operations in the terrorist campaign—its primary role being that of rescue. The Dragonflies were also used on crop-spraying, intelligence work, trooping, air-supply. On February 1, 1953, the flight was re-formed as No 194 Sqn, the first RAF helicopter squadron. The Dragonflies were not withdrawn from Malaya until June 1956.

Another type of RAF helicopter, the Bristol Sycamore, entered service in February 1952. Later versions (HR. 13 and 14) were used to equip No 275 Sqn at Linton-on-Ouse, re-formed by Sqn Ldr D. C. L. Kearns as the RAF's first search-and-rescue squadron in the UK. It moved to Thornaby in 1954 and last year was re-numbered No 228 Sqn.

Sycamores augmented Dragonflies in No 194 Sqn in Malaya in 1954 and in November 1956 were used to equip No 284 Sqn (Sqn Ldr Peter Fahy) at Nicosia in Cyprus. There they carried out remarkable work during the EOKA campaign. They were also used to good effect during anti-Mau Mau operations in Kenya; and at Port Said in 1956 six Sycamores and six Whirlwinds of JEHU transported Commando assaults —Sqn Ldr Kearns winning a DSC, the first awarded for helicopter operations. Sycamores have carried out notable rescue work around UK shores; Whirlwinds have been operating in Malaya since 1955, equip (together with Sycamores) No 22 (ASR) Sqn, and are used by the Queen's Flight at Benson. For future RAF helicopter operations, the Bristol 192 is shortly coming into service; and at the Central Flying School, Little Rissington, a Saunders-Roe Skeeter is based for the instruction of Army pilots.

Helicopters in past or present RAF service: Top, left to right, the R-6 and R-4; second row, Dragonfly, Whirlwind and Sycamore; at right, the Skeeter

"Flight" photogra

NEWS IN BRIEF

Air Cdre D. A. Creal has been appointed to the Australian Air Board as Member for Supply and Equipment, with the rank of air vice-marshal.

D.H. Comet 2s of No 216 Sqn, RAF Transport Command, have flown more than 10,000hr in the past twelve months and brought their total flying time up to 26,000hr.

Gp Capt J. M. Birkin has been appointed honorary Air Commodore of No 3604 (County of Middlesex) FCU, RAuxAF.

We record with regret that the Dowager Viscountess Trenchard, widow of Marshal of the RAF Viscount Trenchard, died in hospital at Uxbridge on March 6 at the age of 74.

Lt-Gen Habes Majali, C-in-C of the Jordanian Armed Forces, was visiting RAF Stradishall last Friday and the RAF College at Cranwell and No 8 FTS (RAF Swinderby) on March 14 and 15 respectively.

The Battle of Britain Fighter Association has launched a drive to trace about 150 ex-RAF aircrew members who, although entitled to wear the Battle of Britain clasp, are not members. Clasp holders who do not belong to the Association are invited to write to the Secretary at Air Ministry (Room 0211), Whitehall, London SW1.

No 804 Sqn of the Fleet Air Arm is bei presented with a tiger called Emperor by t Paignton Zoo as a mascot.

AVM A. D. Selway, who is Commande of the ATC in Scotland in addition to h posts as AOC No 18 Group and Senior RA Officer Scotland, was opening a new ATC gli ing school at RNAS Abbotsinch last Sunda

The fifth RAF Anniversary Concert at th Royal Festival Hall on April 6 will be the la official appearance of Wg Cdr A. E. Sims, wh has been RAF Organizing Director of Musi since 1949.

The RAF Flying College Association annua dinner is being held at RAF Manby on Thurs day, June 9. The honorary secretary, Sqn Ld F. W. Westley, asks members to note the da and states that further details will be circulate to them in due course.

A Valiant of No 543 Sqn carried out an ai survey of Agadir on March 10. Copies of th prints are to be made available to the Moroccan Government. The aircraft took off from S Mawgan at 1030hr, made four runs over th town and returned to Wyton at 1815hr. It wa captained by the squadron commander, W Cdr C. G. St D. Jefferies.